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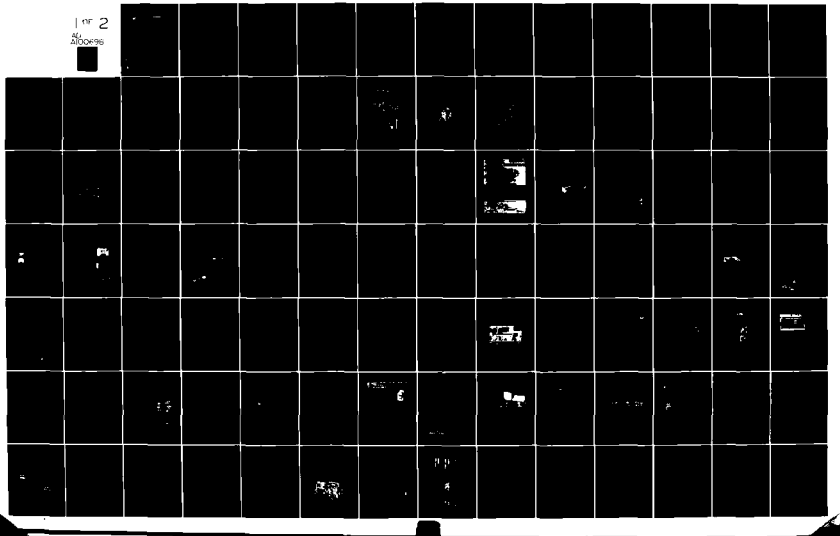

NAVAL AIR ENGINEERING CENTER
LAKEHURST, N.J.
08733

NAEC-92-146

LEVEL II

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APPLICATION OF AN IN-LINE CONTAMINATION MONITORING UNIT TO THE AHT-64 HYDRAULIC TEST STAND

Handling and Servicing/Armament Division
Support Equipment Engineering Department
Naval Air Engineering Center
Lakehurst, New Jersey 08733

4 JUNE 1981

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Commander, Naval Air Systems Command
AIR-340E
Washington, DC 20361

NAEC-92-146

APPLICATION OF AN IN-LINE CONTAMINATION MONITORING UNIT TO THE AHT-64 HYDRAULIC TEST STAND

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Superintendent

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a support engineering analysis establishing parameters, including vibration environment, for development and application of an in-line contamination monitor on the Portable Hydraulic Test Stand AHT-64 to indicate attained degree of particulate decontamination of return hydraulic fluid. Approaches are evaluated, concepts presented and recommendations made.

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PREFACE

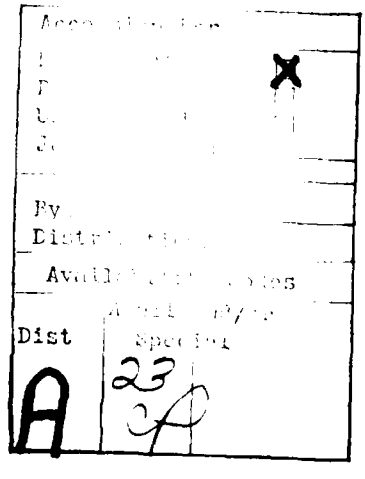
Vibration sensitivity, which appeared as a major shortcoming of in-line hydraulic system monitors in a previous RDT&E 6.2 program, is a necessary parameter to be included in the development of a procurement specification for hydraulic contamination monitors. The report NAEC-GSED-105 (Development of a Procurement Specification for an In-line Contamination Monitoring Unit) prepared a free-standing, two-wheeled cart for the contamination monitor; however, because of a desire to avoid further proliferation of Ground Support Equipment (GSE), the NAVAIRSYSCOM opted for a test-stand-mounted in-line contamination monitor. Mounting on a hydraulic test stand requires the monitor to withstand the vibration signature of the test stand making vibration sensitivity of monitors a critical factor.

This report establishes vibration parameters for contamination monitors which will withstand the vibration levels experienced on the AHT-64 hydraulic test stand. In comparison with other current inventory test stands, the AHT-64 emits the highest levels of vibration because it is a diesel-powered pump unit. Vibration tests of the AHT-64 indicate normal vibration amplitude to be 2 G at a critical frequency of 360 Hz.

A search of available commercial in-line contamination monitors and subsequent testing of candidate models at the vibration signature levels of the AHT-64 revealed a monitor which functions with no distortion. The concept of employing an in-line contamination monitor on a hydraulic test stand is feasible and vibration sensitivity data for the report NAEC-GSED-105 is established.

Consideration is given to application of the contamination monitor to the AHT-64 test stand. This consideration examines requirements for the physical package, location on the stand, piping, electrical and structural changes to accommodate the monitor package plus incorporates portability to allow movement from stand to stand. A listing of drawings affected in the application of the monitor to the test stand is included plus a general statement of changes to these drawings.

This report recommends development of the in-line contamination monitor concept in its application to the Portable Hydraulic Test Stand, AHT-64.



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I. INTRODUCTION

A. BACKGROUND. NAEC-GSED-105 (reference (a)) established the feasibility of an in-line hydraulic system contamination monitor to provide a "go-no go" type indication of hydraulic fluid particulate contamination for aircraft hydraulic systems. Vibration sensitivity, indicated as a shortcoming in NAEC-GSED-105, became a critical factor when the Naval Air Systems Command (NAVAIRSYSCOM) rejected the free-standing, two-wheeled cart concept proposed for the monitor and opted for an AHT-64 hydraulic test stand (reference (b)) mounted monitor. An in-line monitor thus mounted must withstand the vibration of the AHT-64, a diesel powered test stand with a nine-piston axial hydraulic pump experiencing high levels of vibration.

B. OBJECTIVE. This report provides engineering data establishing the vibration signature of the AHT-64 hydraulic test stand. The report also provides data indicating the ability of candidate contamination monitors to operate satisfactorily at the vibration signature levels of the test stand. Further objectives are the examination of locations on the test stand for an in-line contamination monitor, selection of the optimum location and investigation of the various factors involved in the development, fabrication and application of a monitor package to the test stand. This application objective is to provide a suitable monitor with simple operation and "go-no go" indication of hydraulic fluid particulate contamination. The application also examines the feasibility of interchange of the monitor package from one test stand to another.

C. APPROACH.

1. In order to fulfill the foregoing objectives, the feasibility for locating an in-line monitor on the test stand was investigated. When NAVAIRSYSCOM opted for a hydraulic test stand mount for the contamination monitor, a study of possible locations on the test stand was initiated. Evaluation of possible locations on the AHT-64 hydraulic test stand, the selected test vehicle for a stand-mounted contamination monitor, indicated a rear-mounted monitor location to be most feasible. Rough sketches of a proposed concept for this location are included in the body of this report.

2. Examination of requirements to satisfactorily locate the monitor on the rear of the AHT-64 indicates a modification of the test stand piping, electrical system and support structure is necessary. Modifications are detailed in Section II.

Ref: (a) NAVAIRENGCEN Technical Report NAEC-GSED-105 of 14 Jun 1977: Development of a Procurement Specification for an In-line Contamination Monitoring Unit, Final Report (Prepared by J.J. Coyle for NAVAIRENGCEN).

(b) NAVAIRSYSCOM Technical Manual NAVAIR 17-15BF-66 of 1 Nov 1977: Portable Hydraulic Test Stand, Diesel Engine Driven, Operation and Maintenance Instructions with Illustrated Parts Breakdown (Teledyne Sprague Engineering).

3. A literature search of available commercial particle contamination monitors was conducted and characteristics compared and evaluated. Support requirements for these monitors revealed the necessity for providing a motor pump unit, an inverter to provide 120 VAC of sufficient wattage to power both motor pump unit and monitor, and a debubbler to extract entrained air from the return line of the aircraft prior to passage through the monitor transducer or sensor.

4. With required components established, selection and packaging of these components in a minimum size package was investigated. Component arrangement was developed, and a package design concept formulated. A listing of primary components of the monitor package is as follows:

a. Transducer
b. Electronic Signal Analyzer
c. Hydraulic Oil Pump
d. Electric Motor
e. 28 VDC to 120 VAC Inverter
f. Debubbler Unit

Assembling these components into a package 18 inches wide by 18 inches high by 12 inches deep appears feasible. Figure 1 is a representation of the contamination monitor concept as applied to the rear location of the AHT-64 hydraulic test stand.

5. The package concept requires hydraulic quick-disconnect type fittings and flexible hoses and an electrical harness with Cannon-type connectors in order to be readily removed and reconnected to another test stand. All of the six primary components are contained within the 18" x 18" x 12" package.

a. External hydraulic connections to disconnects on the test stand, which effect a bypass from the return line from the aircraft (within the piping in the stand directly behind the suction return connection port) to the package oil pump, thence through the debubbler, to the transducer, and then return through flexible hose to the test-stand disconnect and into the return line downstream from the pickup point.

b. The external electrical connections from the contamination monitor package to the test stand employ flexible cable with Cannon plugs on each end. This cable brings in the 28 VDC from the test-stand altenator to the inverter, the 120 VAC output of which operates the transducer light source, electronic signal analyzer, and the pump motor. An output signal from the signal analyzer operates a "go-no go" indicator light when desired hydraulic decontamination level is achieved. The "on-off" switch for the monitor and the "go-no go" light may either be located adjacent to each other on the test-stand control panel or elsewhere within clear view of the operator. Both "on-off switch and "go-no go" light may be mounted directly on the monitor package as long as the view path and access is clear from the test-stand control panel.

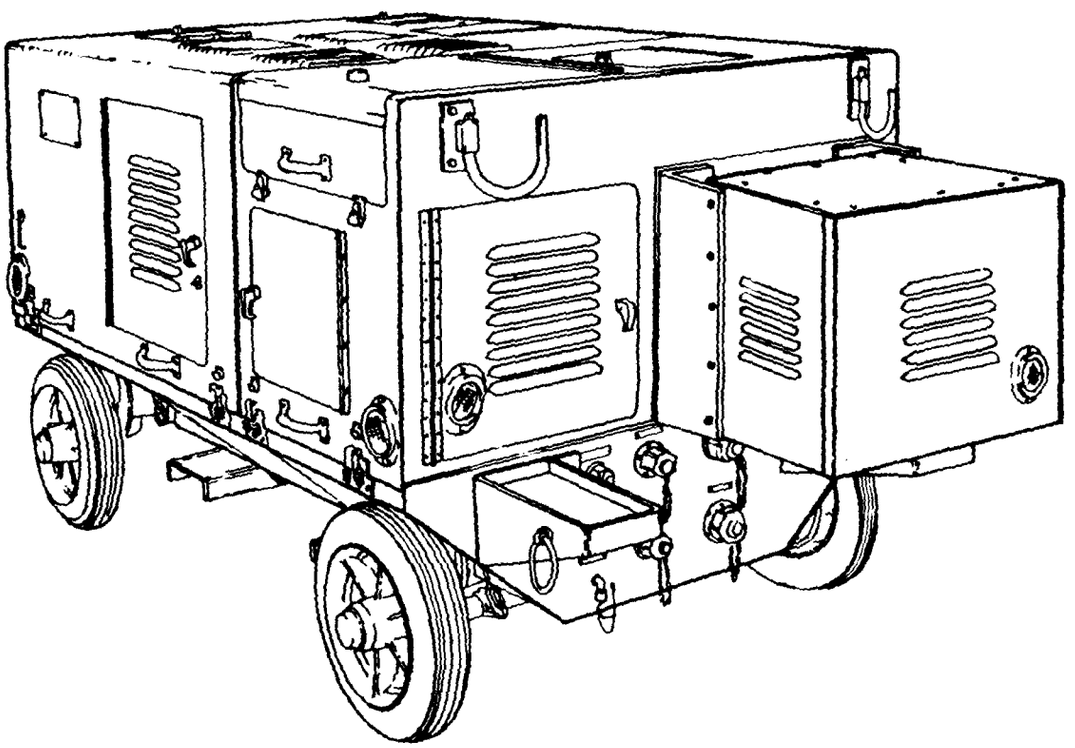


Figure 1. In-line Contamination Monitor Unit on AHT-64 Hydraulic Test Stand

6. A search of available oil contamination monitors adaptable to in-line monitoring has been made and a tabulation compiled indicating features such as size, weight, adaptability for this application, estimated cost per unit and chronological data. Discussions of the various monitors appear in Section II and brochures of specifications for each are included in Appendix A. The candidate in-line monitors from Table I, Page 12, have individually varying characteristics. Generally, they are sensitive to entrained particulate contaminants ranging on the small end of the scale between 10.0 and 0.5 microns, sense entrained air as particulates, and because they use light attenuation and reflection as a means of measure, do not provide a good indication of the presence of water in the oil-based fluids. Monitors having very small flow passages in the sensing area of the transducer are subject to blockage by large particles and require reverse flow capability to clear the transducer. For this reason, only those monitors capable of exceeding a minimum flow rate of 3 gpm through the transducer appear to be suitable for the "go-no go" type indication and for providing the relatively low maintenance desired. The Mean Time Between Failures (MTBF) due to contaminants in transducers is unknown and would need to be determined for the candidate monitors selected.

7. Resolution of the critical factor of vibration sensitivity raised in NAEC-GSED-105 has been accomplished by a two-step effort. These investigative steps are detailed in Section II.

a. The first step, determination of the vibration signature of the equipment on which the in-line monitor is to be mounted, has been established and is reported in Appendix B. The AHT-64 hydraulic test stand, during operation, has a normal amplitude of 2 G at a critical frequency of 360 Hz as determined by test.

b. With vibration levels of the test-stand platform for a monitor established, the second step required is to find a monitor capable of satisfactory operation in such a vibrational environment. An in-line contamination monitor has been found which does operate satisfactorily in the AHT-64 vibration environment. A test report of this determination is included in Appendix C.

II. EQUIPMENT AND PROCEDURES

A. LOCATION OF MONITOR ON AHT-64 TEST STAND. Subsequent to a NAVAIRSYSCOM decision to locate a contamination monitor on the AHT-64 hydraulic test stand, occasioned by a desire to avoid proliferation of Ground Support Equipment (GSE) in aircraft environments, investigation into location possibilities for a typical monitor package revealed five possible locations on the test stand: three on the top, one aft within the hose stowage area, and one below between the fork pockets in a heavy steel enclosure.

1. TOP LOCATIONS. The three top locations were eliminated primarily because of the undesirable feature of added height to the test stand but also because of structural complexity required to provide adequate support, plus the disadvantage of relatively long hydraulic lines through areas where the lines will hamper maintenance. For some models of the available contamination monitors, hydraulic lines must be as short as possible because monitor response lags with increase of line length.

2. BETWEEN FORK POCKETS LOCATION. Investigation of the space between the fork pockets eliminated same as a location for a monitor for the following reasons:

a. Insufficient depth to accommodate components of the monitor package.

b. Vulnerability to fork tines even with a relatively heavy steel closure to the monitor package space between the test-stand fork pockets.

c. If sealed against road dirt and water, heat dissipation of motor, pump, inverter and electronics would be a problem.

d. Difficult access to the monitor for maintenance.

e. Such a location would greatly impair ease of transfer of the monitor to another test stand.

3. REAR PANEL LOCATION

a. The location aft within the hose stowage area is most advantageous for the following reasons:

(1) Easy access to the monitor package.

(2) Easily mounted onto aft pipe frame and bedplate of trailer chassis.

(3) Readily configured for short hose quick disconnects for both hydraulic and electric lines, thus simplifying the change kit for adapting AHT-64 stands to receive a contamination monitor.

(4) The high visibility of this location from the operator's position at the control panel allows both "on-off" switch for the monitor and the "go-no go" light indication of state of oil decontamination to be mounted directly on the contamination monitor package.

b. A disadvantage appears for this rear location - vulnerability to damage by having the monitor package extend aft beyond the chassis of the test stand. This disadvantage may be resolved by either extension bumpers in the area of each rear tie-down ring or by stiffening all support structure members for the monitor package. The extension bumpers appear to be the most feasible resolution.

B. INVESTIGATION OF AVAILABLE MONITORS.

1. MONITOR SEARCH. A search of available particle contamination monitors revealed eight companies that produce monitors of varying degrees of applicability for contaminant monitoring on hydraulic test stands. Of these, two monitors were actually subjected to tests and only one of these operated satisfactorily.

a. Cost Range, Volume and Weight. Known costs of monitors investigated ranged from a low of $3,500.00 to a high of $17,000.00. There is also a rather large variance in the size and weight, the smallest and lightest of these with a volume and weight of 0.37 cubic foot and 10.5 pounds respectively. The other extreme is over 12 cubic feet and approximately 150 pounds and has the highest cost. Because of a desire to assemble the smallest possible contamination monitor package, only those units on the low end of the size scale were tested.

b. Equipment Presentations. Representatives of the following monitor suppliers have brought their equipment to the Naval Air Engineering Center (NAVAIRENGCEN) and/or discussed the application with NAVAIRENGCEN Support Equipment Engineering Department (SEED) and Sanders and Thomas personnel at the NAVAIRENGCEN: Environment/One Corp.; Leeds and Northrup Co.; Gam Rad, Inc.; Micro Pure Systems, Inc.; and Millipore Corp.

c. Monitor Suppliers. The eight monitor suppliers contacted for data applicability to the AHT-64 are as follows (those who gave equipment presentations are preceded by an asterisk):

*(1) Environment/One Corp.
2773 Balltown Road, Schenectady, NY 12309
Attn: W. W. Aker (518) 346-6161

*(2) Leeds and Northrup Co., Microtrac Division
Dickerson Road, North Wales, PA 19454
Attn: F. Dempsey/R. Snyder (215) 643-2000

*(3) Gam Rad, Inc.
46101 Grand River, Novi, MI 48050
Attn: W. E. Helke (313) 348-1005

*(4) Micro Pure Systems, Inc.
2 Oakwood Place, Scarsdale, NY 10583
Attn: Tonis Oja (914) 723-0896/(401) 231-9429

(5) HIAC Instrument Division, Pacific Scientific Co.
4719 W. Brooks St., Montclair, CA 91763
Attn: G. Shinbrot (516) 543-1310/(714) 621-3965

(6) Spectrex Corp., 3594 Haven Ave., Redwood City, CA 94063, Attn: J.M. Hoyte (415) 365-6567

*(7) Millipore Corp., Ashby Rd., Bedford, MA 01730, Attn: R.W. Schaefer (800) 225-1380/(617) 275-9200

(8) Royco Instruments, Inc., 141 Jefferson Drive, Menlo Park, CA 94025, Attn: S.P. LaVallee (617) 891-5320/(415) 325-7811

2. MONITOR PARTICULARS. Table I lists the eight contamination monitor manufacturers, physical characteristics, model data, cost where known, and pertinent chronological data relating to the investigation.

a. HIAC Particle Counter Availability. HIAC Instrument Division, Pacific Scientific Company particle counter PC-120 is owned by NAEC and used at the Franklin Institute and NAEC Tribology Laboratory. HIAC PC-120 was made available for consideration a[illegible]t for the test stand application. Model PC-120 has been replaced by [illegible] PC-320 which is readily adaptable to a "go-no go" type indication [illegible] of oil contamination.

b. Static Bottled Flui[illegible] Spectrex Corporation laser particle counter is configured to [illegible]minants in bottled fluids (such as beer), laser scans a static [illegible] requires a 15-second cycle. Spectrex did not appear interest[illegible]a [illegible]ication of their product to suit this application, however, did fo[illegible] literature on their product.

c. Extreme Vibration Sensitiv[illegible] Royco Instruments Inc. manufacture very sensitive particle counters [illegible]able for particulates as small as .5 microns, capable of determining particle concentrations, and providing digital readout for simultaneous automatic counting of multiple particle size ranges. The Royco unit is extremely sensitive to vibration as evidenced by the experience at NAEC in the Tribology Laboratory, and could not be adapted to an AHT-64 mounted monitor package. Vibration sensitivity of the Model 220 required mounting on a vibration isolation table even within the Tribology Laboratory because of structure-borne disturbance by machinery located at a considerable distance but in the same hangar building.

C. SIZING OF CONTAMINATION MONITOR COMPONENTS. NAEC-GSED-105 indicated that the contamination monitor proposed for the wheeled-cart concept would have dimensions of 18" by 18" by 43" high including handles, wheels and storage space for connecting electric cable and hydraulic hoses. By locating a contamination monitor on the AHT-64 test stand, the electric cable and hydraulic hoses are reduced to a minimum, requiring either a very small or no internal stowage space and the steering handle and wheels are eliminated. With these reductions in required volume and by optimum arranging of the components, a package 18" x 18" x 12" deep appears feasible, with both the electrical cable and hydraulic hoses normally remaining connected to the test stand. Individual components are examined for size, weight and compatibility in the following paragraphs.

TABLE I. COMMERCIAL PARTICLE CONTAMINATION MONITOR SEARCH

COMPANY	MONITOR	COST	CHRONOLOGICAL DATA
Environment/One Corp. Schenectady, NY 12309	Transducer Cat #D-1012N-007, S/N 130 2.38" x 2.38" x 4.50", 2.0 Lb Signal Conditioner Cat #B-101-00002G2, S/N 00013 6.5" x 8.5" x 11", 8.5 Lb	$3,500	Displayed equipment in Trib Lab 12 Jun 1979. Equipment on loan to Franklin Institute for test Nov 1979.
HIAC Instrument Div., Pacific Scientific Co. Montclair, CA 91763	Analog Particle Counter Model PC-120 6" x 8" x 14", 20 Lb Sensor Cat CMB-1.0 2" x 2" x 5.8", 2 Lb	$ -	NAVAIRENGCEN-owned Model PC-120 on loan to Franklin Institute for test Nov 1979.
Leeds & Northrup Co. No. Wales, PA 19454	L&N Microtrac SSM Cat #C4.7123-DS 25" w x 11" h x 7-1/4" d, 50 Lb	$4,600	19 Dec 1978 meeting in Trib Lab displayed and discussed Microtrac SSM - Principle applicable to AHT's but package is much too large. 3 Oct 1979, Demo and seminar at Travel Lodge, Mt Laurel, NJ - same conclusions prevailed as on 19 Dec 1978.
Millipore Corp. Bedford, MA 01730	Millipore Micro Scan-2 7" x 10" x 14", 12 Lb	$8,000	28 Mar 1979 meeting at Trib Lab discussed adaptation of Millipore monitor to in-line monitoring and degree of sensitivity. No info as of Nov 1979. At best 4 micron detection in H_2O - Sensing reaction to hyd fluid unknown.
Royco Instruments Inc Menlo Park, CA 94025	Sensor & Flow Controller Model 220 10-1/2" h x 16-3/4" w x 18-1/2" d 32 Lb (Optics too vibration-sensitive for this application)	$ -	Royco construction too sensitive to vibration per experience in Trib Lab with Model 220 - Optical system is not rigid enough for any but Lab conditions.

TABLE I. COMMERCIAL PARTICLE CONTAMINATION MONITOR SEARCH (CONTINUED)

COMPANY	MONITOR	COST	CHRONOLOGICAL DATA
Spectrex Corp. Redwood City, CA 94063	Laser Particle Counter Model ILI 1000 Cat #67000 18" h x 12" w x 24" d, 31 Lb	$7,600	Unit configured to monitor contaminants in bottled fluids or transparent pipes. Laser light source not employed as continuous monitor.
Gam Rad, Inc. Novi, MI 48050	Enviro Monitor Fluid Analyzer Model 260 FA-128A Sensor, PN 2576 11" x 11" x 9" (approx), 12 Lb FA-166 Control Station PN 2575 8" x 8" x 12" (approx) 15 Lb (approx)	$3,150	Demo in pit at Trib Lab 1 May 1979, returned unit 23 May 1979. Model 260 fluid analyzer with control station was demonstrated by Bill Helke on setup with small pump. Sensitivity of unit was immediately evident with introduction of 2 mg/l AC fine dust into system. If light source will withstand vib levels of AHT-64, can adequately monitor oil contamination from aircraft - readily adaptable to "go-no go" type indication for use on stand. Light source is incandescent. Vibration characteristics unknown.
Micro Pure Systems Inc Scarsdale, NY 10583	Micro Contaminant Monitor Model 1100 - $16,000 Fluid Line Inspection Chamber - $1,000	$17,000	Units displayed and described in Trib Lab Nov 1979. Indications are that this equipment is satisfactory for Laboratory use only.

1. SIGNAL ANALYZER. Of the eight monitors listed in Table I, three appear to be suitable for possible application to the AHT-64 package. These are:

a. Environment/One Corp.
Signal Conditioner Cat # B-101-00002G2, S/N 00013
Dimensions 6.5" x 8.5" x 11"
Weight 8.5 Lb

b. HIAC Instrument Div., Pacific Scientific Co.
Analog Particle Counter, Model PC-120
Dimensions 6" x 8" x 14"
Weight 20 Lb

c. Gam Rad, Inc.
Enviro Monitor Fluid Analyzer, Model 260
FA-166 Control Station PN 2575
Dimensions 8" x 8" x 12"
Weight 15 Lb

2. TRANSDUCER OR SENSOR. The pickup sensor or transducer for use in conjunction with each of the above three models follow. Of these the Gam Rad Inc., FA-128A Sensor PN 2576 is least desirable because of size and weight, requiring more volume and weighing nearly as much as its matching electronic control station. It can, however, be made to fit into a projected monitor package.

a. Environment/One Corp.
Transducer Cat #D-1012N-007, S/N 130
Dimensions 2.38" x 2.38" x 4.50"
Weight 2.0 Lb

b. HIAC Instrument Div., Pacific Scientific Co.
Sensor Cat CMB-1.0
Dimensions 2" x 2" x 5.8"
Weight 2 Lb

c. Gam Rad, Inc.
Enviro Monitor Fluid Analyzer, Model 260
FA-128A Sensor PN 2576
Dimensions 11" x 11" x 9"
Weight 12 Lb (Approx)

3. MOTOR PUMP FOR HYDRAULIC FLUID. Of the three remaining candidate monitors, the Environment/One Corp. unit requires the greatest flow rate, a minimum of 3 gpm. The pump unit selected for the monitor package for sizing purposes will deliver 5.46 gpm at 100 psi and 1,200 rpm. Typical pumps operating at this range can be purchased flange mount coupled directly to end cap of motor. A typical motor for this pump requirement is 1/3 hp, 1,200 rpm and provides a package within the limiting dimensions of the proposed monitor package size. If the motor is 28 VDC, frame size would have to be larger to accommodate the additional copper in windings but the inverter requirement would not then need be sized to accommodate the motor load. Motor pump size projection of 9" x 9" x 18" is predicated on use of Vickers Pump Model No. V210-5-1C-12-5214, flange mounted on a motor of NEMA frame size 182 or 184.

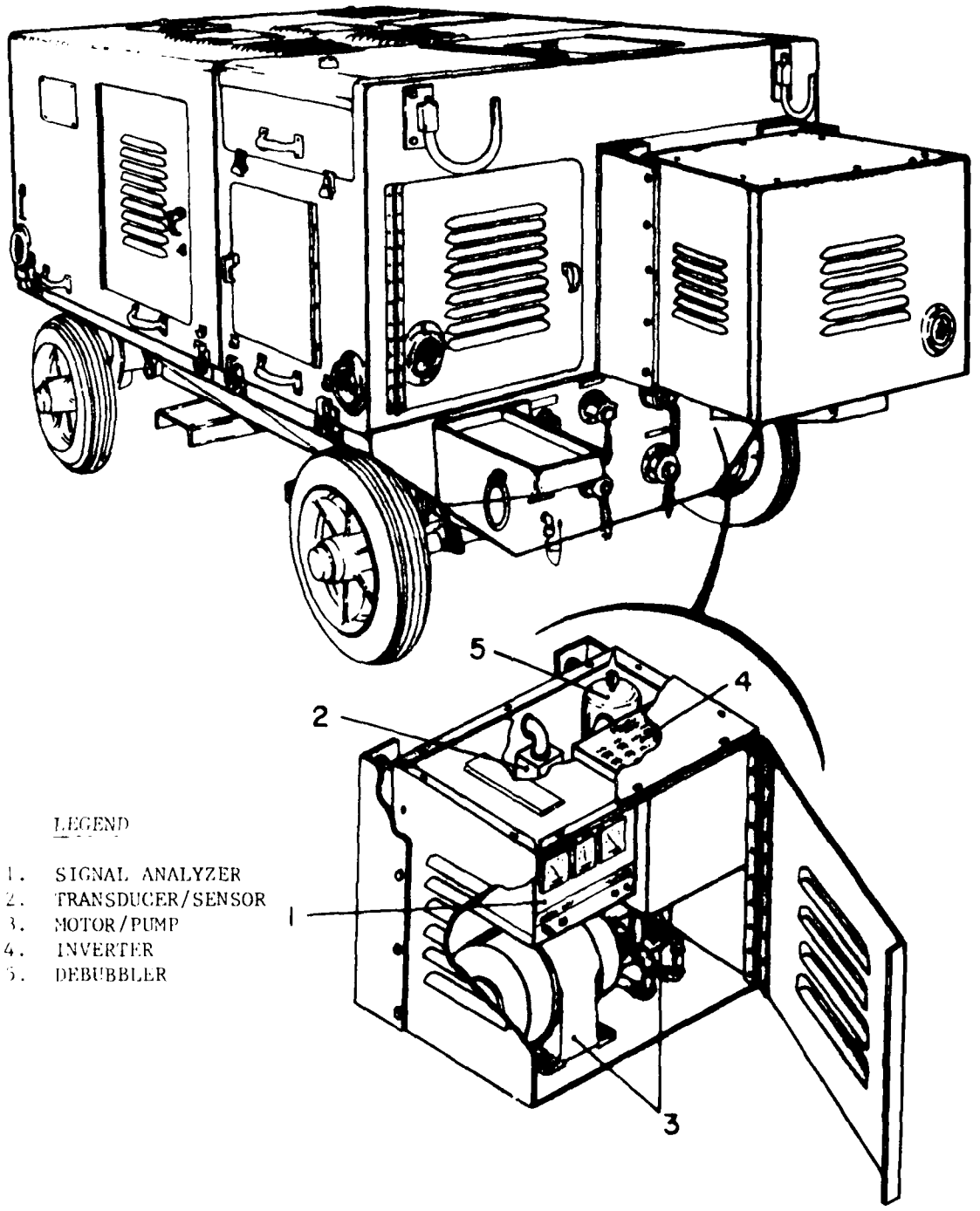
Estimated weight of this motor pump unit is 45 pounds. See Appendix A for reprints of pump and motor data extracted from the Vickers Catalogue.

4. 28 VDC TO 120 VAC INVERTER. Sizing of the inverter required to operate the monitor package is based on a demand for 115 VAC by three units in the monitor: the circulator pump motor, the signal analyzer and the transducer or sensor. In each case of the three candidate monitors the transducer or sensor is powered through the signal analyzer. The maximum wattage is 150 for Gam Rad's "Enviro Monitors", the minimum 10 watts for Environment/One. Allowance for the 115 VAC pump motor and the analyzer transducer package of 500 watts total, with a 2-to-1 surge capability for starting the motor, is planned. For planning purposes a DC-to-AC inverter, Model 1172 heavy-duty 500-watt square-wave inverter, manufactured by Wilmore Electronics Co. Inc. (see EEM/1980, 81 p. 3495, Vol. 2), is selected with dimensions of 7" x 8-1/2" x 11" and weighing 32 pounds. A reprint from the EEM catalog is included in Appendix A.

5. DEBUBBLER. During particulate decontamination of an aircraft hydraulic oil system, entrained air in the return line is read as particulate matter by contamination monitors; thus any gasses must be removed before the oil passes through the transducer or sensor. To accomplish this, a debubbler installed in the line upstream between the return line and the sensor will vent trapped gasses. A typical debubbler or deaerator requires a vertical cylinder approximately 4 inches in diameter by 14 inches high and weighs approximately 14 pounds (with system full).

D. SIZING AND ARRANGEMENT OF CONTAMINATION MONITOR PACKAGE. An estimated size for the monitor of 18" x 18" x 12" deep appears reasonable based on the size of commercially available components. Packaging of these components within this space is tight; however, by mounting units on bottom and back only, with front, sides, and cover removable, access to components will be adequate. All vertical faces of the container, including the door, will be louvered in order to dissipate heat buildup from motor, pump, inverter, and debubbler. Figure 2 shows an arrangement whereby the components may be contained in the proposed package as well as a representation of the monitor package as applied to the AHT-64 test stand.

E. REMOVAL AND REPLACEMENT CAPABILITY. In order to provide a monitor package that can be easily removed and replaced on the AHT-64 test stand, a change kit needs to be developed for attachment to the test stand. A typical change kit provides a mount for the monitor package which rests on and is bolted to the bedplate of the chassis and is bolted to mounting lugs welded to the component assembly bridge. Figure 3 shows the location for the mounting lugs on the component assembly bridge and the area for bolting the support to the chassis bedplate. In order to provide ventilation from the p[illegible] and filter area of the test stand, the mount employs vertical angles as stand-offs to allow for this ventilation and also to provide space to bring out lines for electrical and hydraulic connections. Figure 4 shows a conceptual arrangement of this mounting method on the AHT-64.



LEGEND

1. SIGNAL ANALYZER
2. TRANSDUCER/SENSOR
3. MOTOR/PUMP
4. INVERTER
5. DEBUBBLER

Figure 2. Contamination Monitor Arrangement on AHT-64 Test Stand

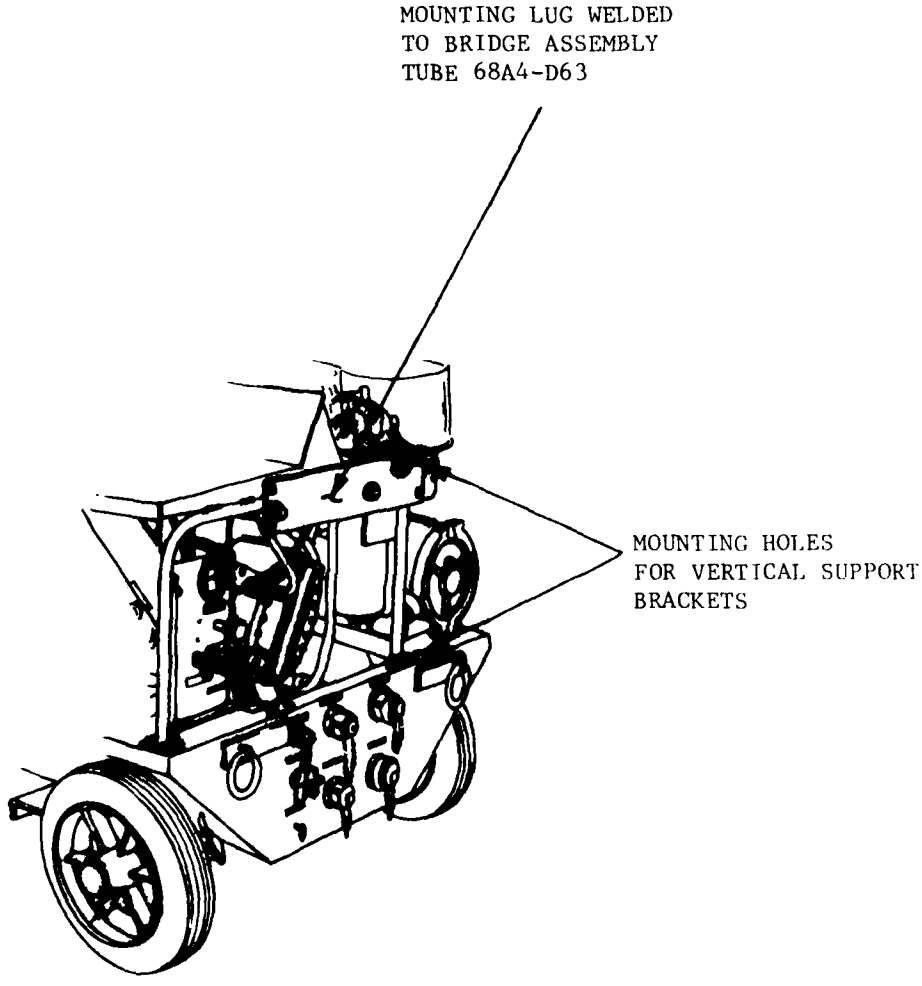


Figure 3. Mounting Lugs and Attachment Points to AHT-64 Chassis

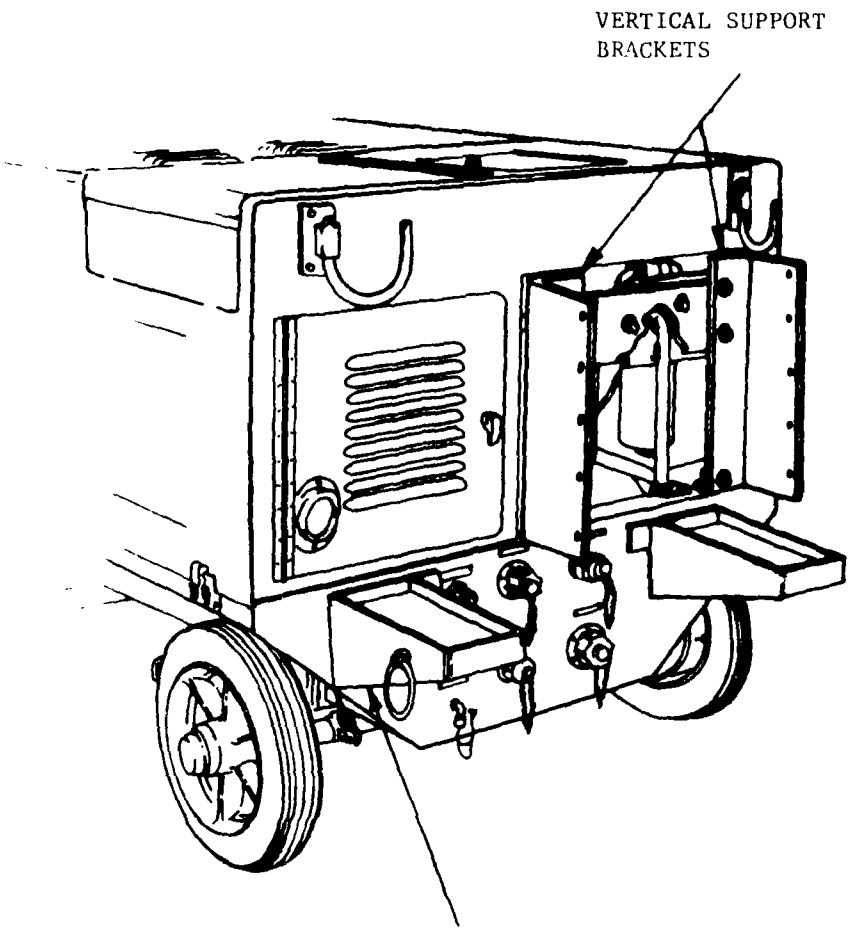


Figure 4. Mounting Arrangement for Monitor on AHT-64 Test Stand

1. ELECTRICAL CONNECTION. The change kit necessarily includes a wire harness to connect the 28 VDC output from battery/alternator system to a Cannon plug on the exterior of the stand behind the location of the contamination monitor. A mating connector from the contamination monitor then connects the monitor to the stand.

2. MONITOR-STAND HYDRAULIC CONNECTION. Hydraulic connections from the test stand to the monitor include two hydraulic lines tapped from tees in the hydraulic return line within the test stand (behind the return connector from the aircraft)to quick disconnects on the stand behind the monitor package. Short flexible lines extend from the monitor couple to these disconnects for the pickup and return flow through the transducer. The return flow from the monitor transducer is to the downstream tee in the low-pressure return line.

F. ELECTRICAL INTERCONNECTION WITH TEST STAND

1. 28-VDC POWER SOURCE. Electrical power needed for the contamination monitor is provided by a line from the positive side of the battery and alternator as shown on electrical schematic diagram, Figure 1-10 of NAVAIR 17-15BF-66; the line runs through the ignition switch to a Cannon plug on the back of the test stand, thence to an "on-off" switch in the monitor package. The monitor "on-off" switch is connected to the 28-VDC to 120-VAC inverter and thence to ground. The 120-VAC 500-watt output from the inverter connects to the pump motor and signal analyzer. An interconnection from the signal analyzer powers the transducer or sensor.

2. POWER CABLE. To provide an easy electrical disconnect capability, a short flexible cable extends from the rear of the monitor package for connection to the Cannon plug on the test stand. When the monitor package is removed from its mount on the hydraulic test stand, the connecting electrical cable may be stowed within the package.

G. HYDRAULIC INTERCONNECTION WITH TEST STAND. Interconnection with the test stand may be made by incorporating a pickup tee and tube in tube assembly-5 of piping installation Part No. 68A4-J800-1 (Figure 9-4 of NAVAIR 17-15BF-66). This pickup tube extends to a point behind the mounting area of the monitor and terminates in a coupling half. The mating half to this coupling connects with the inlet side of the monitor package pump through appropriate hose, couplings, fittings and tubing. After passage through the components in the monitor package, a discharge line passes through appropriate tubing, fittings, and hose back to another coupling half on the test stand. The mating coupling half on the test stand discharges into tube assembly-6 of Part No. 68A4-J800-1 through appropriate tube and fittings. The interconnecting hoses may be removed from respective couplings on the test stand and monitor package and stowed with the monitor package when the monitor is to be transferred to another test stand.

H. PHYSICAL ADAPTATION TO STAND STRUCTURE. Previous discussion and evaluation has established the location on the rear of the test stand as optimum for the monitor package. Paragraphs II.E.1 and II.E.2, when considering removal and replacement capability from the rear location, refer to mounting the monitor

package on the tube (68A4-D63-1) of the bridge assembly (68A4-J614 or 68A5-J610) and to the rear panel-assembly top surface (68A4-F31 or 68A4-J607) of the chassis assembly (68A4-J20 or 68A4-J903). Lugs welded to the tube (68A4-D63-1) will absorb horizontal forces imposed at the top of monitor mounts, and vertical loads will be absorbed by the top flange of the rear panel assembly (68A4-F31 or 68A4-J607). A mounting structure as represented in Figure 4 will be bolted to the lugs on the bridge assembly tube and to the rear panel assembly. This mounting structure is fabricated from structural angles and steel plate. A cutout in the rear end housing (68A4-F17) will enable the end housing to be removed without removal of monitor mounts. The cutout portion will be secured to the monitor mount to maintain present closure and ventilation. An external box shown on some models of the rear panel assembly, presumably added for stowage of the fill system outlet hose, will be removed. Other stowage for this hose may be readily accomplished.

1. MAINTENANCE CONSIDERATIONS. The foregoing modification and structural additions to the AHT-64 test stand will not impair any operations of the stand, and added structural members for the monitor may be readily removed if disassembly is required. Mounting lugs welded to the bridge assembly tube do not interfere with any assembly/disassembly procedures of the stand. Other supports are bolted to the chassis. Unions at the connection points to the hydraulic suction return line tube assemblies will make added piping above the chassis bedplate removable if required during any major teardown of the test stand.

2. OPERATION AND MAINTENANCE CHANGES. Maintenance and operations are less convenient with the addition of the monitor package to the stand. The high-pressure filter will be more difficult to change and attachment of the coupling end to the suction return connection port will require the operator to secure same from a squatting position. The present stowage arrangement on the test stand for pressure outlet and suction return hose is not compromised by the addition of the monitor package. The hose storage manifold and valve will be more convenient to use if rotated 90° with the valve handle extended aft rather than down. Provision of bumpers on the aft panel of the chassis and location of the monitor package will negate vulnerability occasioned by this valve rotation.

3. TEST-STAND PARTS AFFECTED. A listing of test-stand components requiring change to accommodate the in-line monitor and a description of the change is indicated in Table II. The part number column lists those part numbers for Teledyne Models 68A4-J600 and 68A4-J800. Where duplication items appear in the description column, these are to accommodate the differences between models.

TABLE II. TEST-STAND PARTS CHANGES FOR MONITOR

DESCRIPTION	TELEDYNE PART NO.	CHANGE TO DRAWING
Bridge Assembly*	68A4-J54	Add welded lug for monitor support
" " *	68A4-J55-1	" " " " " "
" " *	68A4-J614	" " " " " "
Chassis Assembly	68A4-J20-9	Show added holes for support brackets
" "	68A4-J607	" " " " " "
" "	68A4-J903-1	Show reqd holes for support structure
Component Assy Bridge	68A4-J613	Show welded mounting lug on drawing
" " "	68A4-J902	" " " " " "
Component Assy Rear Housing	68A4-F612	Show cutout, remove reflector and hose storage
Hyd Test Stand Assy	68A4-J600/ -J800	Modify sheets of assy to show monitor
Internal Component Assy	68A4-J2	Change view sheets 4, 5 and 6
" " "	68A4-J601	" " " 2, 4, 5, 6 and 7
" " "	68A4-J901	Change B/M and view sheets 3, 4, 5 and 6
Piping Installation	68A4-H731	Add tee in tube 68A4-D404-29 for pickup
" "	68A4-H731	" " " " 68A4-D571-23 for return
" "	68A4-H913	Change elbow MS51521820 to tee for pickup
" "	68A4-H913	Add tee in tube 68A4-C921-1 for return
Rear End Housing	68A4-F17-1	Make cutout for clearing supports, remove hose storage box 68A4-C16-1, remove right hand reflector from housing
Rear Housing Assy	68A4-F610	Change view to show changes on 68A4-F17-1
Rear Panel Assy	68A4-F31-1	Add bolt hole for mounting bracket on top flange of -11, add bumper extension brackets and relocate tie-downs
Right-Hand Side Panel Assy	68A4-F21-1	Add mounting bolt hole to 68A4-608-1 top rear
Wiring Installation	68A4-D741-1	Add connecting cable to monitor switch
" "	68A4-D586	" " " " " "

* These 3 assemblies have lug welded to tube, bridge assy 68A4-D63.

I. EVALUATION OF CANDIDATE MONITORS

1. GENERAL. In paragraphs II.B and II.C, investigation of the eight candidate monitors revealed in a data search eliminated all but three models. Details of all eight candidates are listed in Table I and reasons for rejecting five discussed. The remaining three were considered for their size, weight and compatibility in a proposed monitor package. Of the three candidate monitors, the Environment/One Corp. signal conditioner and transducer were the only units which had been flight certified and had seen service in the Navy's A-7 aircraft. Also the Environment/One unit is the smallest and lightest. Pertinent data of these three candidate monitors appear in Table III.

2. AUXILIARY COMPONENTS AND PARAMETERS. Each of the three monitors require an auxiliary circulator pump, a 28-VDC to 120-VAC inverter, and a debubbler to extract entrained air from the hydraulic fluid in order to be adaptable to the AHT-64 test stand.

a. Power requirements for each of these monitors is of relatively slight significance in light of the fact that the pump motor starting torque demands an inverter capable of providing an estimated 500 watts at 120 VAC.

b. Contamination monitor package size and weight are very nearly the same for each of these three monitors since the motor pump unit, debubbler and inverter account for approximately 65% of the package volume and approximately 85% of the weight.

c. Operating pressure for these monitors in the AHT-64 aircraft return line environment will always be less than the lowest rated pressure of the three monitors.

d. Shock will not be a critical factor for this application because the mass of the test stand will effectively attenuate imposed shocks below critical levels of monitor components. Any revealed sensitivity to shock may be readily cushioned for such small components as employed in the monitor package. Vibration as a factor influencing performance of in-line contamination monitors is discussed in the following paragraphs.

J. VIBRATION SIGNATURE DETERMINATION OF TEST STAND. The vibration sensitivity pointed out as a deficiency of in-line contamination monitors in report NAEC-ASED-105 has been overcome through a two-step process. The first step of the process is determination of the vibration signature of the vehicle on which the contamination monitor will be mounted. The second step is determining the capability of candidate monitors to withstand the vibration levels of the carrying vehicle. The following paragraphs present the findings of the vibration signature investigation of the AHT-64 hydraulic test stand. The AHT-64 was selected as the vehicle on which to mount an in-line contamination monitor because, of all the mobile hydraulic test stands, it appears to experience the highest level of vibration. This high level of vibration is caused primarily by the diesel engine drive of its 3,000-psi, 28-gpm, nine-piston pump. Also the AHT-64 is a high inventory test stand.

TABLE III. CANDIDATE MONITOR EVALUATION

TYPE DATA - COMPONENT	ENVIRONMENT/ONE SIGNAL CONDITIONER/ TRANSDUCER	HIAC PC 120	GAM RAD ENVIRO MONITOR
Volume: Analyzer	0.352 Cu Ft	0.390 Cu Ft	0 445 Cu Ft
Sensor	0.015 Cu Ft	0.002 Cu Ft	0.631 Cu Ft
Total	0.367 Cu Ft	0.392 Cu Ft	1.076 Cu Ft
Weight: Analyzer	8.5 Lb	18 Lb	15 Lb (Approx)
Sensor	2.0 Lb	2 Lb	12 Lb (Approx)
Total	10.5 Lb	20 Lb	27 Lb (Approx)
Pressure: Operating	100 Psig	85-3,000 Psi	250 Psi (Approx)
Test	600 Psig	-	325 Psi
Operating Temperature:			
Analyzer	200° F	-	190° F
Sensor	350° F	200° F	190° F
Input Power	117 V 47-400 Hz 10 W	110-240 VAC 50-60 Hz 40 W	117 VAC 50-60 Hz 150 W
Sensor: Shock	15 G	-	-
Vibration	50 G at 2,000 CPS	-	-
Analyzer: Shock	15 G (on board model only)	-	-
Vibration	2.2 G at 3,600 CPS	-	-
Particulate Range	2 + PPM	0-100, 0-300, 0-1K, 0-3K PPM	50 PPB to 50K PPM
Flow-Rate Range	3-20 Gpm	Uniform flow rate	0-75 Gpm
Cost Per Unit	$3,500	$10,000 (PC-320)	$3,150

1. COMMERCIAL TEST COMPANY SELECTION. A number of commercial companies were contacted to provide monitoring equipment for use by NAVAIRENGCEN laboratory personnel. Response was extremely varied in cost both for purchase and rental of equipment with lead times extended and costs high. The NAVAIRENGCEN Test Department Electronic Division and a number of commercial testing companies were requested to quote on performing vibration signature analysis of candidate AHT-64 test stands. This service was provided by:

Vibration Specialty Corporation
100 Geiger Road, Philadelphia, PA 19115

The vibration signature analysis is reprinted in Appendix B.

2. VIBRATION SIGNATURE ANALYSIS. A vibration signature analysis of two AHT-64 hydraulic test stands was performed, one at Naval Air Engineering Center, Lakehurst, and one at Naval Air Station, Willow Grove, PA, (stand 143 and 117 respectively), to determine existing vibration amplitudes and frequencies.

a. Vibration energy was monitored at seven locations on the test stand as shown in Figure 5. Signatures were recorded in the horizontal, vertical, and axial directions under idle (1,000 rpm), full-speed (2,400 rpm), loaded (3,000 psig), unloaded and transient conditions. Each signature (see Appendix B) shows vibration amplitude in G acceleration versus frequency in Hz. The amplitude (vertical scale) is logarithmic with full-scale equal to 1 G or 10 G as indicated. The frequency (horizontal scale) is linear from zero to 2,000 Hz with 4 Hz resolution. Described in the heading are test stand number, test position, total overall vibration level, various instrument settings, and test stand operating conditions.

b. Vibration amplitude response varied by a factor of two or more between the two test stands due to structural integrity differences, not input energy differences. Vibration frequency response was consistent on both test stands - that is, 360 Hz was the major source and response frequency.

c. Basically all input energy was measured at positions 6 and 7, Figure 5. Test position 6, Figure 5, was the hydraulic pump, where loaded (3,000 psig) and unloaded (zero gauge) pressure variations were tested. Measured and recorded were the change in vibration energy levels produced by the two conditions.

d. Stand 143 showed a considerable increase in vibration (almost double) with load (see Appendix B, Figures 20 and 41). Stand 117 showed very little increase (about 10 percent), as seen in Figures 60 and 77 of Appendix B. The major vibration frequency was 360 Hz, or nine times the operating speed (2,400 rpm = 40 Hz). It was determined that the pump had nine pistons working axially, which explains the high ninth harmonic response in all test positions, predominantly in the axial direction.

e. Test position 7, Figure 5, was the diesel engine on both stands, rotating at 2,400 rpm, with or without pressure load on the pump. The engine vibration levels recorded on each stand were very similar, and there were no appreciable changes with pump loading (Appendix B, Figures 22, 43, 62 and 78). The major frequency source from the diesel was the 40 Hz signal and the associated harmonics.

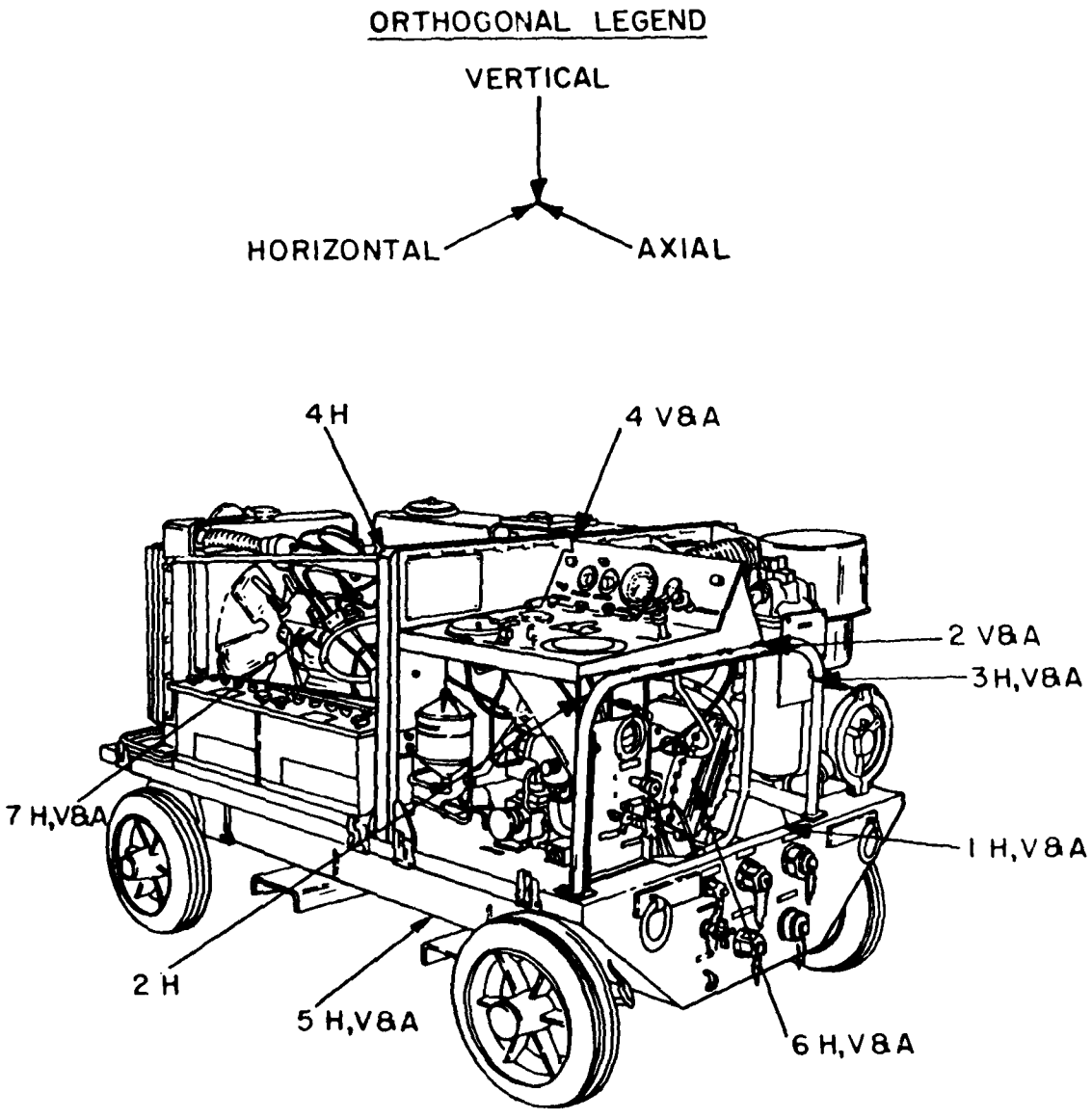


Figure 5. AHT-64 Vibration Test Positions

f. Structural vibration response was measured and its frequency spectrum signature recorded at five different locations on the AHT-64 structure. Remember, the major frequency on all signatures on both test stands was 360 Hz.

g. The highest amplitude response (2.2 G) on stand 143, was at position 5, Figure 5 (Appendix B, Figure 36), which is the underside of the base structure of the stand. A level almost equal to this (2 G) was recorded in the axial direction at positions 1 and 3, Figure 5 (Appendix B, Figures 26 and 32). Positions 2 and 4, Figure 5, showed levels around 1.5 G (Appendix B, Figures 29 and 35).

h. In comparison, test stand 117 had the highest response (7 G) at position 4, Figure 5 axial (Appendix B, Figure 73). The next highest response on stand 117 was 3 to 4 G's (still higher than 143) at positions 2 and 3, Figure 5 (Appendix B, Figures 67 and 68). Positions 1 and 5, Figure 5, had levels around 1 to 2 G.

i. The only explanation for this drastic difference in response between these two test stands would be the way the control panel is connected to the rib structure at those points. In other words, stand 143 is stiffened by the ribs being rigidly connected together by the control panel, and stand 117 is less rigid by being loose or possibly not connected at all, thereby allowing this center point to vibrate excessively. Upon examination, bridge-assembly mounting bolts were found to be loose and several welds on the bridge cracked.

3. ANALYSIS SUMMARY

a. The excitation energy on each test stand was similar, producing a similar frequency response. However, the amplitude response was different by a factor of two or more. Therefore, the instrument package which is to be mounted on the AHT-64 structure must be able to withstand vibration frequencies around 360 Hz. However, the amount of vibration energy it must withstand is still in question.

b. If we assume that test stand 143 had "good" structural integrity and needs no further reinforcements, etc., and we assume that test stand 117 could be fixed and/or reinforced enough to respond similar to 143, then the amount of vibration energy which must be withstood by the instrumentation would be 2 G's if mounted on the rear of the stand below the control panel (positions 1, 2 and 3 on Figure 5).

K. VIBRATION TOLERANCE OF MONITORS

1. After determination of the vibration signature of the AHT-64 test stand, a nondestructive test-bench setup was devised which would allow candidate contamination monitor components to be gradually subjected to increasing amplitudes at the critical frequency of the AHT-64. This test bench enables monitors to be tested for their ability to perform satisfactorily in the simulated vibration environment of the AHT-64.

2. These tests indicate that an in-line contamination monitor does exist which will operate satisfactorily at the AHT-64 hydraulic test-stand

vibration signature. Procedures, results and illustrations of this test-bench setup are included in their entirety in Appendix C. Of the three monitors selected as applicable, two were made available for tests. Of the two which were tested, one proved satisfactory and the other could not be tested adequately because it was determined to be inoperable prior to any vibration excitation. This model, the HIAC PC-120, is no longer manufactured and has been replaced by a Model PC-320 which can be provided with a signal closure device for automatic shut-off at a predetemined degree of fluid particulate decontamination. Vibration sensitivity of PC-320 is unknown.

III. CONCLUSIONS

A. Determination of the vibration signature of the AHT-64 hydraulic test stand provides amplitude and frequency data required to complete the hydraulic contamination monitor specification in NAEC-GSED-105, Development of a Procurement Specification for an In-Line Contamination Monitoring Unit.

B. A commercial in-line contamination monitoring unit has been satisfactorily tested for operation at the critical frequency and amplitude of the AHT-64 hydraulic test stand.

C. A contamination monitor package concept has been developed which is adaptable to the AHT-64 hydraulic test stand.

D. The modification of AHT-64 test stands to incorporate an in-line contamination monitor is compatible with present operation and maintenance procedures of the test stand.

IV. RECOMMENDATIONS

A. Development of an in-line contamination monitor package is recommended. This will include assembly of primary components in a common enclosure, mounting on a test stand and operating for an engineering evaluation.

B. It is recommended that concurrent with development of the in-line contamination monitor a modification kit be developed for adaptation of the monitor to the AHT-64 hydraulic test stand.

C. The vibration signature data contained herein should be added to the procurement specification NAEC-GSED-105, Development of a Procurement Specification for an In-Line Contamination Monitoring Unit.

V. REFERENCES

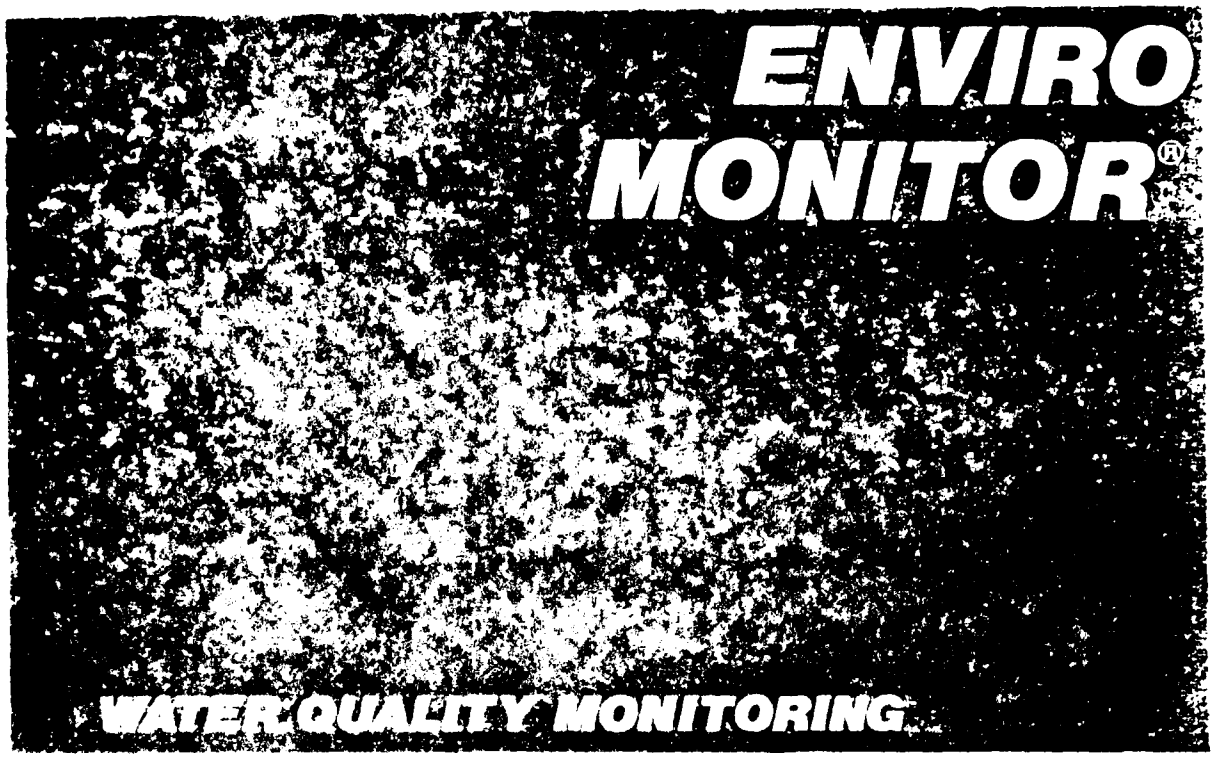
(a) NAVAIRENGCEN Technical Report NAEC-GSED-105 of 14 Jun 1977: Development of a Procurement Specification for an In-Line Contamination Monitoring Unit, Final Report (Prepared by J.J. Coyle for NAVAIRENGCEN)

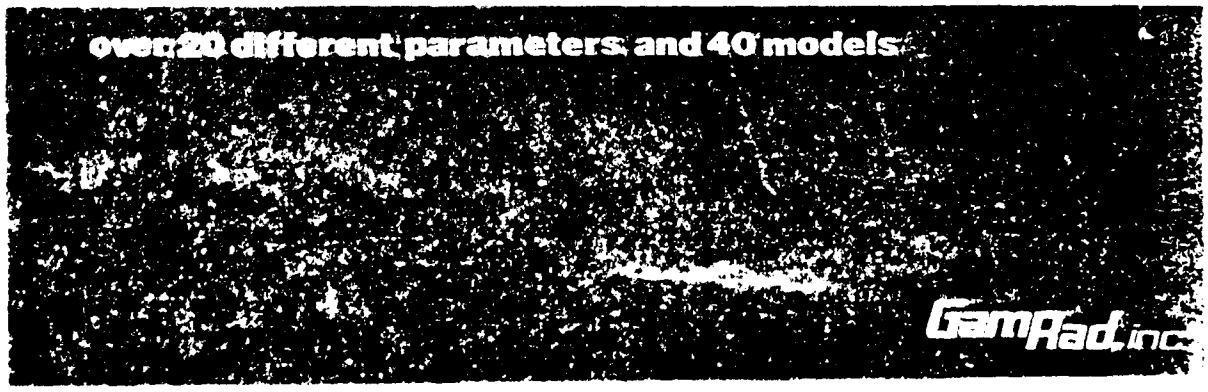
(b) NAVAIRSYSCOM Technical Manual NAVAIR 17-15BF-66 of 1 Nov 1977: Portable Hydraulic Test Stand, Diesel Engine Driven, Operation and Maintenance Instructions with Illustrated Parts Breakdown (Teledyne Sprague Engineering)

APPENDIX A

MANUFACTURERS' DATA FOR CANDIDATE IN-LINE CONTAMINATION MONITORS

The manufacturers' data is presented in the following order:


ENVIRO
MONITOR®
WATER QUALITY MONITORING


over 20 different parameters and 40 models
GamRad inc

This partial list of parameters indicates the many instrument systems available in the Enviro Monitor line. If your particular requirement is not listed, don't hesitate to contact the factory for recommendations.

AMMONIA
CALCIUM
CHLORIDE
CHROMIUM, HEXAVALENT
CONDUCTIVITY
COLOR
DISSOLVED OXYGEN
DISSOLVED SOLIDS
FLOW
HARDNESS
NITRATE
NITRITE
ORP
ORTHOPHOSPHATE
pH
POTASSIUM
RESIDUAL CHLORINE
SELECTIVE ION
SODIUM
SULFIDE
SULFUR DIOXIDE
SUSPENDED SOLIDS
TEMPERATURE
TURBIDITY *

* Meets EPA design criteria.

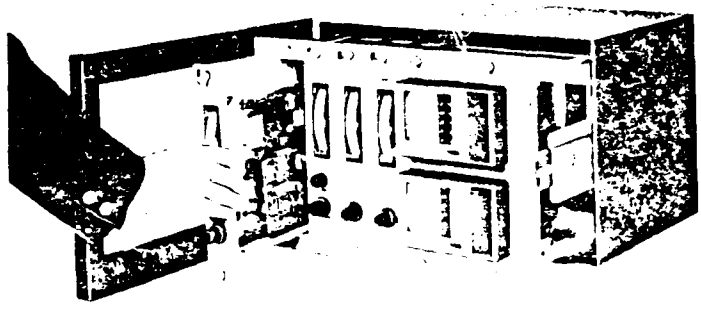
Introduction to Enviro Monitors

Enviro Monitor describes a series of water quality instruments that are divided into three major categories:

Single Parameter	Series 500
Multiparameter	Series 1000
Wet Chemistry	Series 2000

A single Series 500 and each channel of the Series 1000 Enviro Monitor provides the same total capability. These separate series are available to fulfill the need for single or multiparameter monitoring. The Series 2000 Wet Chemistry Enviro Monitors are available for applications that require complex sample treatment prior to measurement.

Enviro Monitors offer single-source capability for monitoring all water quality parameters. This means total instrument requirements for measurement and/or control of influent, effluent, or process water quality can be satisfied by a single source. Gam Rad, Inc. Enviro Monitors utilize state of the art electronics and proven technology to provide the best optimum system.



Enviro Monitor Benefits

Shopping around to mix and match instruments is a thing of the past. By specifying Enviro Monitors you benefit in many ways. For example, single source capability also means single source responsibility. You no longer have to be concerned with incompatible instruments.

Further benefits are derived from continuity in packaging, electronics, materials, construction, power requirements, readout and output standardization, instruction and service manuals, and most of all by integrated technical assistance. In keeping with this concept, we offer engineering specifications and application data sheets.

For over ten years Gam Rad has manufactured instruments to meet customers' needs. That service is yours for the asking. You don't have to settle for off-the-shelf instruments to meet special requirements. Enviro Monitors have been designed to offer custom instruments at off-the-shelf prices.

GAM RAD IS . . .

a diversified, multi-product company that has been producing water quality monitoring instrumentation for over a decade. With the expanded ENVIRO MONITOR line, we are *now prepared to solve all of your water quality monitoring needs.*

Our business is building these instruments, at competitive prices, to meet the needs of our customers.

ENVIRO MONITOR BENEFITS . . .

Single source capability also means single source responsibility, and that means benefits like these:

- Compatible instruments, physically and electronically
- Continuity in packaging, electronic materials and construction
- Standardized readouts and outputs
- Standardized input power requirements
- Integrated technical assistance

IF YOU'RE IN NEED OF OUR EXPERTISE IN WATER QUALITY MONITORING, CONTACT OUR LOCAL REPRESENTATIVE OR FACTORY PERSONNEL.

represented by

46101 Grand River
Novi, MI 48050
313/348-1005

Printed in U.S.A. P/N 5500-0001

NAFC-92-346

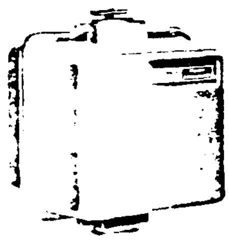
BULLETIN T 400

Fluid Analyzers

GAM RAD, INC.

Monitor suspended solids (turbidity) in process streams with these accurate, dependable instruments. Designed to meet modern process application requirements. Ultra-pure materials to slurries. Monitor and control your process with assurance.

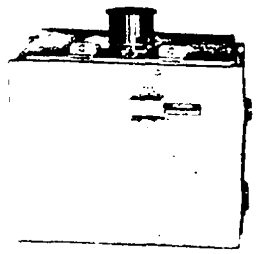
Model 370-A Fluid Analyzer



1 PPB To 50,000 PPM total range

The Model 370-A is designed for applications demanding the utmost accuracy particularly with ultra-pure materials down to **one part per billion** concentrations. Optical system incorporates unique dual light beam dual detector arrangement for extreme sensitivity. Measures 90° scattered light from suspended solids with almost instantaneous response. BULLETIN T 200

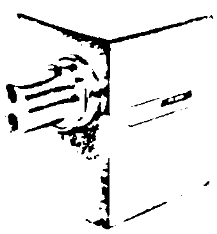
Model 260 Fluid Analyzer



50 PPB to 50,000 PPM total range

The Model 260 incorporates a single light beam, single detector optical system to measure 90° scattered light. Low end sensitivity is **50 parts per billion**. May also be set up to measure transmitted light (absorbance) when needed. Designed for applications where less sensitivity and range is required. BULLETIN T 100

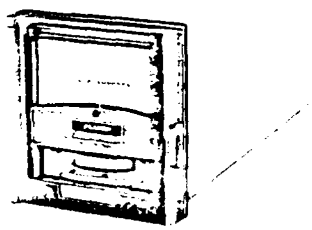
Model 150 Fluid Analyzer



10 PPM to 150,000 PPM (15%) total range

The Model 150 is particularly suited for heavier concentrations — up to 15% total solids. There are no limitations on flow rate because of probe type style. Measure light scattered at 130° (back-scattered) from suspended solids. May be installed in process lines of any size or in tanks or vessels. BULLETIN T-300

Control Station



The Control Station provides readout, measuring and control circuitry, power supply and output signal connections for each of the above Sensing Stations. It can be located adjacent or remote up to 500 feet away. Standard panel mounted style shown. Table top styles also available. Features all solid state circuitry, 5" taut band meter and 0-100 millivolt output along with control switches and calibration controls.

PATENTS PENDING

General Features

The Models 260 and 370-A are "flow thru" instruments rated at 75 GPM with less than 2" water pressure drop. 2½" sanitary fittings are standard and flange fittings are optional. The Model 150 has no flow limitation. This is determined by the line size into which it is installed. It, also, is available with 2½" sanitary or flanged fitting.

All Fluid Analyzers are rated at 250 PSIG pressure. Temperature maximums are 140° F for Model 260 and Model 150 and 190° F for Model 370-A. All may be equipped for up to 450° F service.

All models feature **condensation proof windows, electronically controlled light source** and **temperature stabilized detector cells.**

All wetted components are made of type 304 stainless steel. In addition, the flow chambers on the Model 370-A and 260 are Teflon coated. Alternate materials and coatings are available.

All Sensing Stations are suitable for indoor or outdoor installations. Explosion proof housings are available for hazardous locations.

Power requirements are 117 VAC, 50-60 HZ, 150 watts max. Output signal is 0-100 millivolts DC-adjustable. Milliampere or pneumatic outputs are available.

Other options and accessories to meet most process requirements.

Typical Uses

monitor and control -

FILTER EFFLUENTS
CENTRIFUGES
CLARIFIERS
DEMINERALIZERS
SCRUBBERS
POLISHERS
THICKENERS
MIXERS

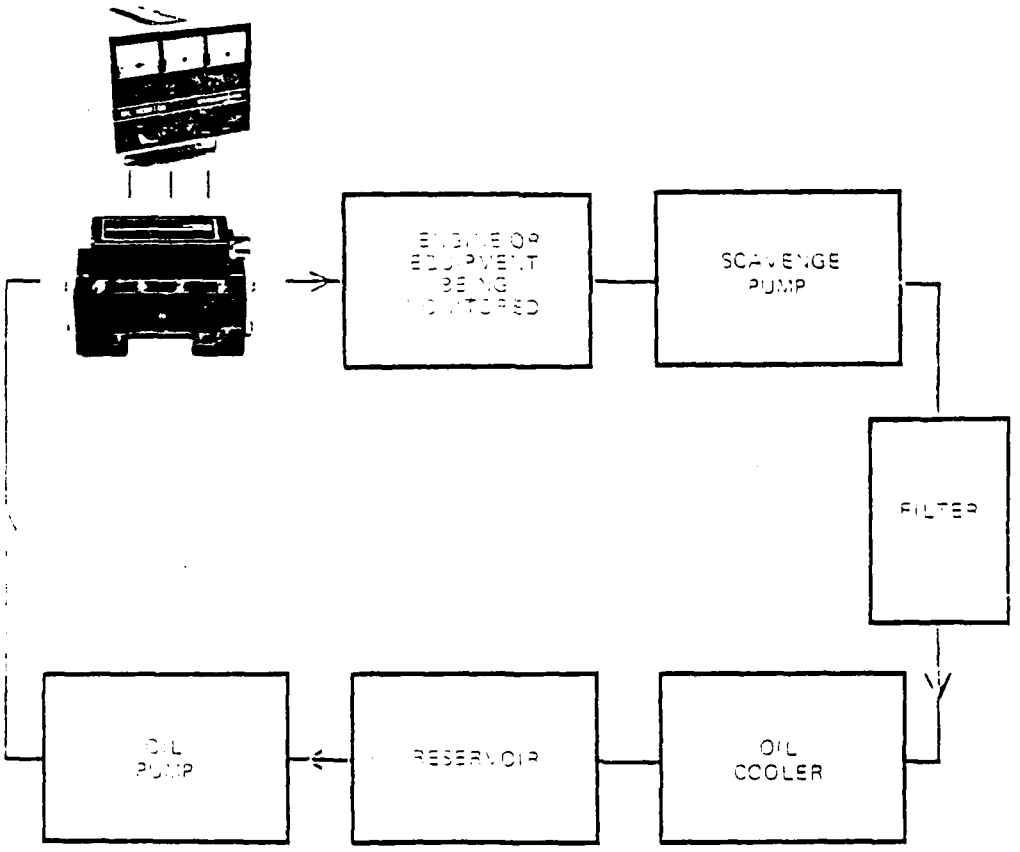
CLARITY
EMULSIONS
CLOUD AND FOG POINTS
PRECIPITATIONS
REACTIONS
SLURRIES

BOILER FEEDWATER
HYDRAULIC OIL
BEER
FRUIT JUICES
POLYETHLYNE
RAW WATER
SPENT PICKLED LIQUOR
ALUMINUM SILICATE
PLATING ELECTROLYTE
INDUSTRIAL WASTES
SILICON
SUGAR
SOLVENTS

GAM RAD, INC.
46101 Grand River
Novi, Michigan 48050
Area Code 313-348-1005

EQUIPMENT CONDITION MONITOR

(OIL MONITOR)



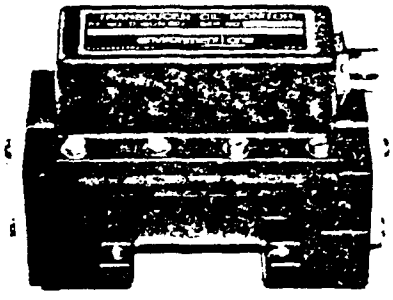
environment one CORPORATION

PROTECTING MAN'S ENVIRONMENT

AN IN-LINE MONITOR WHICH PROVIDES REAL TIME DETECTION AND MEASUREMENT OF METALLIC AND NON-METALLIC PARTICULATE CONTAMINATION AND CHEMICAL/ THERMAL DEGRADATION OF LUBRICATING OILS AND OTHER FLUIDS

FEATURES

- In-line, real time indication of metallic and non-metallic particulate presence and chemical/thermal degradation in oil or other fluids
- Detects ferrous and non-ferrous particulates and dissolved impurities introduced from within or from outside the equipment
- Provides early warning and trending of equipment malfunction
- Automatically and continuously self-calibrating
- Long term, maintenance free, automatic operation
- Individual outputs for particulate presence, chemical/thermal degradation and flow rate

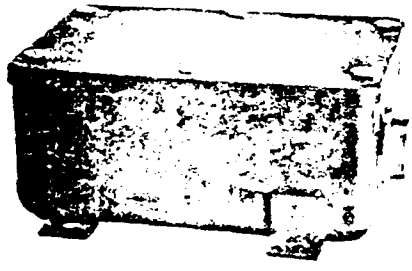


SPECIFICATIONS

TRANSDUCER
Cat. #D-1012N-007

- Operating temperature to 350° F
- Operating pressure to 100 PSIG*
- Pressure drop 5 PSIG at 18 GPM
- Flow rate 3 to 20 GPM
- Shock 15 g's
- Vibration 50 g's at 2000 CPS
- Size 2.38" x 4.50"
- Weight 2.0 lbs.

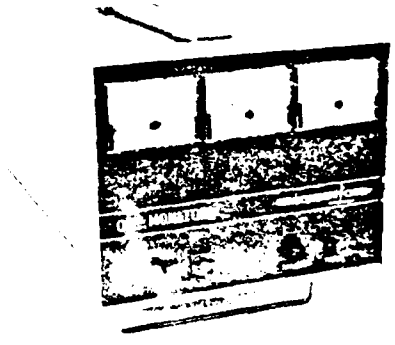
*Tested to 600 PSIG



[illegible] CONDITIONER ON-BOARD*
Cat. #D-10128-010

- Operating temperature to 200° F
- Input Power 28 VDC at 0.3 Amps
- Output 0 to 5 VDC each channel
- Vibration 5 g's at 2000 CPS
- Shock 15 g's
- Size 5.25" x 7.25" x 3.3"
- Weight 3.0 LBS max

*Other configurations available



FUEL CONDITIONER, TEST CELL REMOTE
Cat.#8-101-00002G2

- Visual output on panel meters, 0 to 5 VDC each channel
- Input power 117V, 47 to 400 Hz, 10 Watts
- Size 6.5" x 8.5" x 11"
- Weight 8.5 LBS

INTRODUCTION

The Equipment Condition Monitor is a field proven in-line lubrication system monitor which provides real time incipient failure prediction and degradation rate of oil-wetted parts, oil overheating, excess aeration, inadequate flow, seal failures and other abnormal engine or equipment conditions.

The Equipment Condition Monitor's early warning and trending capabilities can effect genuine economies for the user by

- reducing or eliminating expensive damage to capital equipment,
- minimizing equipment down time,
- reducing maintenance to an "as needed" basis,
- reducing sample frequency and analysis where S.O.A.P. or similar procedures are followed and
- predicting residual operational life of a component.

In addition to lubrication systems, the Equipment Condition Monitor is applicable for other fluids such as fuels, hydraulic or process fluids or others in a circulating system.

SYSTEM DESCRIPTION

The Equipment Condition Monitor System consists of a Transducer mounted in the oil line and a Signal Conditioner located either on-board or at a remote station. For multi-point monitoring, if continual read-out is not required, one Signal Conditioner can accommodate several transducers on a time-share basis.

During operation the oil or fluid is monitored by measuring the light scattering caused by metallic particulates and light attenuation resulting from chemical thermal degradation and non-metallic particulates. An output corresponding to flow rate is also provided. Unique design features which incorporate internal, stable references make the Monitor automatically and continuously self-calibrating over all system operating conditions.

Designed initially for aircraft gas turbine operation, the Equipment Condition Monitor can withstand adverse conditions of temperature, shock and vibration.

TRANSDUCER

The Transducer, designed to accommodate a broad range of flow rates, is normally mounted directly in the high pressure side of the main oil line. In this location the effects of free air in the oil are minimized because most of the air is dissolved. As the oil passes through the Transducer it causes a rotor to turn. The rotor contains fluid passages and optical references which are alternately placed in an optical system as the rotor revolves. The optical paths utilize sealed fiber optics to conduct the light into and out of the oil and to produce a light beam parallel to the axis of the rotor. One photo sensor is mounted radially so that it views the light beam at 90° to provide the scattering output. The attenuation sensor views the axial component of transmitted light. The output of each sensor is a series of pulses alternating between reference and signal. These are fed to a signal conditioner which computes the ratio of signal to reference amplitudes.

SIGNAL CONDITIONER

In the signal conditioner, outputs from the scattering and attenuation sensors are transmitted to their respective, variable gain, current amplifiers which pass only the light pulses and eliminate the DC component due to stray light and dark current. Reference channels compare incoming reference pulses with a fixed voltage reference and provide control signals to change the gain of the current amplifiers thereby providing a continuous and automatic self-calibrating condition.

The outputs of the flow, scattering and attenuation channels provide from 0 to 5 volts dc with a current output capability of 2 milliamperes. These outputs can be applied to condition monitoring multiplexers, A-D converters, recorders, cockpit indicators or other on-board or remote monitoring equipments.

Two additional features include a test mode and a malfunction indication. The test mode will cause the Signal Conditioner to read out the measured scattering and attenuations levels of the Transducer references. This provides a check of the Monitor circuits as well as the read-out equipment. The malfunction indication, which can activate a warning circuit, is initiated by component or power failure or low flow rate.

APPLICATIONS

Designed initially for use as an on-board real time indicator of the optical properties of lubrication oils in aircraft gas turbines, the Equipment Condition Monitor System can be similarly used for continuous or periodic, on-board or remote monitoring of stationary gas turbines vehicular turbines, marine turbines, industrial machinery, gear boxes, fuel systems, transmissions, processing systems and other equipment using circulating fluid systems.

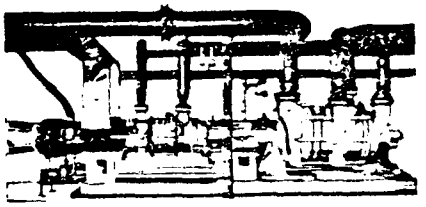
STATIONARY

- Gas Turbines for Power Generation
- Pipeline Engines and Compressors
- Off Shore Drilling Rigs
- Mining Equipment
- Stand-By and Peaking Turbines

AIRCRAFT

- Military Engines and Gear Boxes
- Commercial Airlines Engines
- Helicopter Gear Boxes and Transmissions
- Business and private Jets

PROCESSES



- Flushing Cycle Monitoring
- Filter Evaluation
- Liquid Chemical Monitoring
- Liquid Food Monitoring
- Petroleum Evaluation

MARINE

- Naval Turbines and Hydraulic systems
- Bearing Lube Systems
- Merchant Marine Equipment
- Passenger Ship Turbines
- Turbine Fuel Monitoring

ALSO FOR GAS TURBINES AND ENGINES IN

LOCOMOTIVES
OFF THE ROAD EQUIPMENT
TRUCKS AND BUSES

Since the Equipment Condition Monitor System uses optical techniques, factors such as fluid opacity enter into its feasibility for specific applications such as diesel engine lubricating systems or other reciprocating equipment. Contact us with your application requirements so that we can determine the Equipment Condition Monitor's suitability for your equipment. A simple test can make this determination toward the application of this cost saving system to your requirements.

ENVIRONMENT CARE CORP
2773 BALLTOWN RD.
SCHENECTADY, N.Y. 12309
(518) 346-6161

ECM-3(1M)-6/75

THE IN-LINE OIL MONITOR AND ITS ROLE IN ENGINE CONDITION MONITORING

George F. Skala*

Environment/One Corporation, Schenectady, N. Y.

Abstract

An Equipment Condition Monitor for the continuous in-flight detection of abnormal conditions of oil-wetted engine components has been developed. The system employs the principles of light scattering for particulate debris detection and light attenuation for chemical/thermal degradation. Long-term stability is obtained by an automatic and continuous self-calibration feature using internal references. An output proportional to flow rate also is provided. The system can withstand the adverse temperature, shock, and vibration ambients associated with jet aircraft applications. Flight tests on passenger-type, multi-engine aircraft and on single-engine military aircraft have been conducted. A bearing failure on an endurance test engine was predicted by abnormal oil condition readings prior to any other indications of failure.

Introduction

Until recently, an on-board real-time condition monitoring system has been a conspicuous missing link in airborne engine instrumentation systems. In addition to its functions of lubricating and cooling, the oil is a messenger carrying information which, if heeded, can help prevent some of the 30 to 35% of engine failures caused by oil-wetted components. Engine-installed oil monitoring at present generally is limited to the use of magnetic chip detectors and screens which are periodically examined for collected debris. In some cases, this is supplemented by the Navy pioneered Spectrometric Oil Analysis Program (S.O.A.P.). This can be effective as a preventive maintenance tool if all the human factors from sampling, to analysis, to reporting, to interpreting, and finally to taking corrective action are carefully controlled.

In recognition of the need for continuous oil monitoring, there have been several recent developments which utilize a form of trapping device, such as a magnet or screen, coupled with an arrangement to produce an electrical signal which is a function of the collected debris. The signal is usually generated by a change in resistance, capacitance, or magnetic properties produced by the collected material, or by a pressure transducer monitoring the drop across a filter.

*Manager.

These can provide information only on what they have removed from the oil. Also, in order to produce an output which can indicate the start of an abnormal condition, it is necessary to know the rate at which the debris is being collected. This requires the use of some form of differentiating, or rate of change, circuit that would be difficult to design for sufficient accuracy on a real time basis. Finally, all forms of trapping device require regular maintenance in that they must be periodically cleaned or replaced.

Requirements

For sufficiently early warning, the oil-monitoring system must have adequate sensitivity and long-term stability to detect a significant departure from a long-term trend. For most jet engine applications, this minimum detection level should be no more than the equivalent of about 10 ppm.

To present a true "on-condition" indication, the detection capabilities should encompass all forms of undesirable oil conditions. These would include the detection of wear metals from the engine, dirt from outside the engine, and degradation of the oil. It also would be desirable if the source of contamination could be identified. However, the qualitative analysis techniques that this entails would, at the present state of the art, require an overly complex approach, or a severe limitation of the kinds of contamination that could be detected. For example, the use of radioactive isotope tagging would eliminate the detection of contamination originating from outside the engine. With a universal detector, once an "off-condition" situation develops, conventional ground-based analysis, such as S.O.A.P., can be used to identify the contamination. A truly effective oil-monitoring system also should require little or no maintenance or attention. Since one of the ultimate objectives of engine condition monitoring is to eliminate unnecessary maintenance, the components of such a system should not contribute to any required maintenance. Other, more obvious requirements are that it be reliable small, lightweight, and reasonable in cost.

Design Approach

Because optical sensing is universal, and can be sensitive, this technique was selected for the oil monitoring system developed by Environment/One Corporation. Scattered light is used to detect particulates, and the attenuation of a direct beam detects dissolved impurities.

Optical methods have been in use for some time as sensitive fluid monitors, one example being the measurement of water turbidity. The instruments employed for this purpose are relatively large and often fragile, or mechanically complex, so that a new design concept was developed to meet aircraft requirements.

The major considerations in obtaining stability are to correct for the large temperature coefficients of solid-state photo detectors, and the changes in illumination due to light source variations and window deposits. An optimum

configuration is to use a single optical path, with means to introduce alternately the oil and an optical reference. This is done by mounting the optical references on a rotor which is turned by the flowing oil. In addition to providing the reference function, this causes the light received by the photo sensors to be chopped, so that a.c. amplification, which eliminates effects of stray light and dark current, can be employed.

The references are of glass, designed to duplicate the scattering and attenuation characteristics of partially contaminated oil. Fiber optics are used to transmit light into and out of the oil and to change its direction by 90°. The fiber optics are sealed, so that conventional windows are eliminated. Also, because of the collimating properties of the fiber, lenses are also eliminated.

The light beam is parallel to the axis of the rotor. One photo sensor is mounted radially so that it views the light beam at 90° to provide the scattering output. The attenuation sensor measures transmitted light. The output of each sensor is a series of pulses alternating between reference and signal. These are fed to a signal conditioner which computes the ratio of signal to reference amplitudes. Since the same light source, fiber optics, and sensor are used for the reference and signal, all variations in these components are canceled out.

The transducer, shown in a cutaway view in Fig. 1, is 2.4 in. wide, 4.5 in. long, and weighs 2 lb. In addition to scattering and attenuation photo-transistors a third one is used to generate a gate signal that is used by the signal conditioner to separate the measuring and reference pulses. Because the photo-transistors' peak response is in the near infrared region of the spectrum, the effect of normal oil color variations on the attenuation output is minimized.

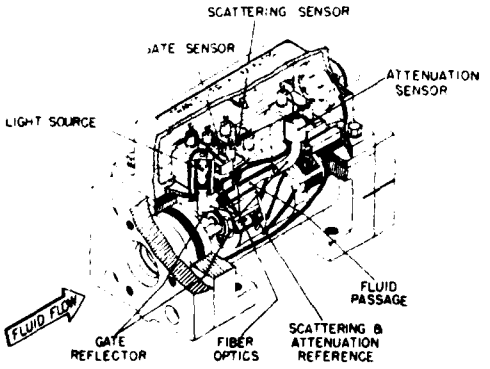


Fig. 1 Transducer.

The transducer is normally mounted directly in the high-pressure side of the main lube supply line. In this location, the effects of free air in the oil usually are eliminated because the air is dissolved in the oil. In one engine installation, in which aeration in the high-pressure line was evident in ground tests, it disappeared at altitudes above 18,000 ft where the air separator was more effective.

The signal conditioner can be mounted

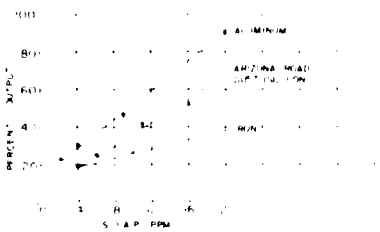


Fig. 2 Equipment condition monitor scattering output; oil temperature, 180°F. Flow = 9 GPM.

in any convenient location. Its size is about 5 x 7 x 3 in., and it weighs 2.5 lb. It provides separate 0- to 5-v d-c outputs proportional to scattering and attenuation. Also, because the rotor frequency is directly related to oil flow rate, a third output of flow also is provided.

The circuit presents a malfunction indication in the event of a component failure in the transducer or signal conditioner power failure, cable failure, or loss of oil flow. There is also a self-test feature by which the correct operation of the oil monitor and its associated read-out equipment can be checked automatically. The signal conditioner circuits also can be supplied on two circuit boards about 3 1/2 x 7 in. for incorporation in the same enclosure with other condition monitoring circuits.

Results

A typical calibration of the scattering channel vs S.O.A.P. is shown in Fig. 2. This does not imply a unique relationship between scattering and ppm content because the size and shape of the particles determine the relative amounts of optical scattering. Another difficulty in correlating with S.O.A.P. is the question of its sensitivity to particles vs dissolved materials. For example, it was necessary to add about 250 ppm of the Arizona Road Dust to obtain a S.O.A.P. reading of 16 ppm, although some of this could have been due to settling out of the large particles in the test oil loop. Figure 2 does not represent the maximum sensitivity of which the system is capable. A several-times increase in sensitivity is possible for applications in hydraulic systems when complete airframe condition monitoring becomes a reality.

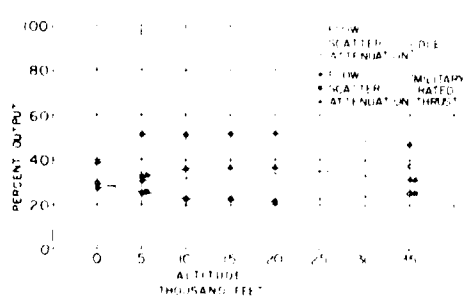


Fig. 3 Equipment condition monitor output; aircraft A7A No. 2658, NATC Patuxent River, Md., Flight No. 1, April 27, 1971.

Figure 3 represents [illegible] on the first flight of a series conducted on an A-7 aircraft at NATC Patuxent River, Md. Tests were at altitudes from sea

IN-LINE OIL MONITOR

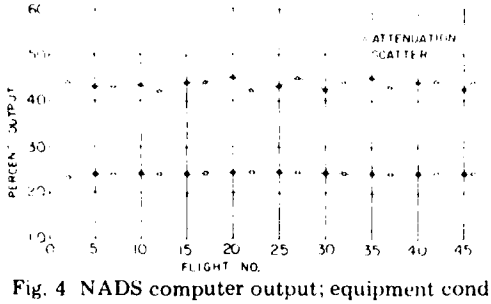


Fig. 4 NADS computer output; equipment condition monitor, aircraft type A7A No. 2658, NATC Patuxent River, Md.

level to 35,000 ft, and at engine speeds from idle to military rated thrust (MRT)' The data show no significant altitude effect but only a change in flow at different engine speeds.

Data at MRT at 5000 ft from other flights of this series are shown in Fig. 4. Most of the flights were of 2- to 3-hr duration, although some were longer, representing cross-country flights to California. Considerable oil was added, although data on how much and when are not available. The flight program was continued for a total of 163 flight hours, with no unusual readings except when oil foaming was deliberately induced by subjecting the aircraft to negative g loads. Carrier arrest landings were also part of the test program. After completion of the flight tests, the oil monitor was removed, and its calibration checked in a test loop. No shift in calibration was detected.

A similar series of tests is now being conducted in which the oil monitor is part of a complete engine condition monitoring system (IECM). In this installation the oil-monitor circuits have been incorporated into the Signal Analyzer Unit of the IECM system.

Figure 5 represents data on a TF41 endurance test engine. This engine experienced an LP compressor thrust bearing failure that was accompanied by high attenuation and scattering readings that occurred prior to other evidences of malfunction. The S.O.A.P. analysis showed an increase in iron content from 8 to 29 ppm when the engine was shut down. The engine was repaired, and a second endurance run of 1065 hr was completed. Again the oil monitor system was removed and checked on a test loop, with no evidence of degradation or calibration shift.

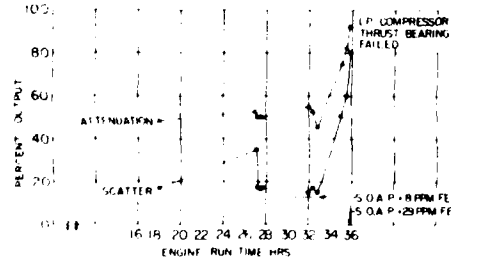


Fig. 5 Equipment condition monitor output; TF41 endurance test, engine S/N 141050 BU9, Oil MIL-L-7808, May 20, 1971.

To date, an estimated minimum of 5000 hr of engine running time has been accumulated by Environment/One's oil-monitoring systems. Except for some problems due to faulty commercial power supplies in early signal conditioners, there have been no reported failures, malfunctions, or false alarms of properly installed systems. In addition to the TF41, the engines on which the monitor has been tested include the TF30, CF6, GE4, F101, and J57. Evaluation testing on the HLH engines, LM2500, TF39, and others is being planned.

Conclusions

A field proven on board real-time oil monitor for use on jet engines, either by itself or as part of an over-all engine monitoring system, is now available. In addition to warning of incipient failure of oil-wetted components, other benefits include:

1) Early detection of failure modes, on development engines or component test rigs, before complete destruction of the failed components. This will allow better analysis of the cause of failure.

2) Because of the ability of the monitor to detect excess air under flight conditions, it can be an aid in the development of air separators.

3) Possible warning of low oil supply by the resultant increase in trapped air.

4) Engine oil changes only when needed, instead of on arbitrary time schedule.

5) Extension of time between overhauls.

NASA-93-146

Model PC-120 Contamination Monitor

& Analog Particle Counter

For continuous on-stream measurement of particles per second, with high or low concentration limit alarm. Four push button ranges: 0-100, 0-300, 0-1000, and 0-3000 particles per second.

Typical applications:

Monitoring
Hydraulic systems clean-up
Ultra clean solvents
Deionized water supplies
Intravenous liquids
Turbine lubricating oils
JP-4 manufacturing

Testing
Filter units: systems (one sensor upstream, one downstream)
Lubricating oils
Hydraulic fluids
Solvents
Fill parts, flush stands, and test stands

Description:

The PC-120 is a single-channel particle counter with an adjustable particle size threshold and a continuous analog output proportional to particles-per-second through the sensor. Outputs can be used for analog meter display, strip chart recorder, automated data acquisition system, and the alarm system (panel lamp or remote device). The automatic alarm circuit signals when upper or lower pre-set concentration limits have been exceeded.

Input may be from the standard HIAC "CM" sensor powered by the PC-120 (with sensor as remote as 1,000') or by other HIAC counters (PC-305, PC-320 or PC-420). Four pushbuttons on the panel face select particle concentration range.

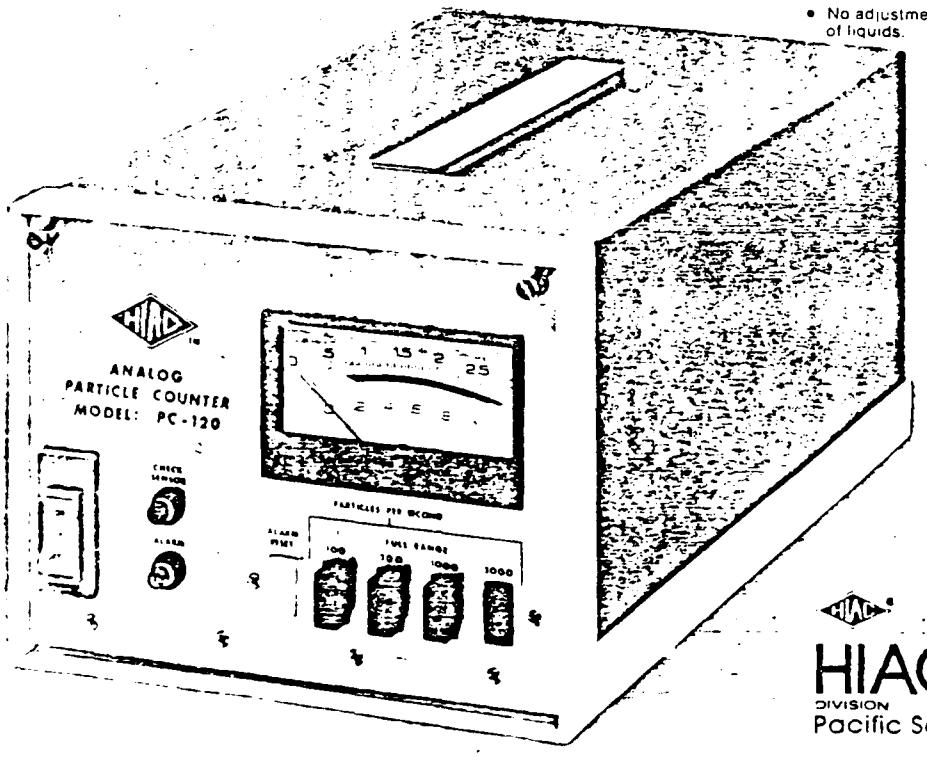
The PC-120 is portable and can be half-rack mounted.

Features:

- Read and plot (with recorder accessory) particle concentration continuously.
- Automatic concentration limit alarm.
- Direct dialing of particle size threshold.

PC-120 Flexibility:

- Connected to the PC-305, PC-320 or PC-420 (short BNC to BNC coaxial cable), it receives the signal from their sensor and provides analog output. Also can be used with 420 "SB" Series sensor through PC-120 sensor cable.
- Can be "prime calibrated" in the field.
- Digital count equivalent on strip chart recorder very close to actual, if flow rate and elapsed time are known.
- Selected interval recording: leave PC-120 on; connect strip chart recorder through ordinary percentage timer.
- Multiple sensor selector switches are available.
- Sensor can be remote to 1,000'. Standard cable is 6' long.
- Sensors rated to 3000 psi and 200°F.
- No adjustment required for varying colors of liquids.



HIAC
DIVISION
Pacific Scientific Company

[illegible] Analog Particle Counter

& Contamination Monitor

SPECIFICATIONS:

Input
- From standard HIAC [illegible] sensor.
- From BNC connect[illegible] at rear of PC-305, PC-30[illegible] or PC-420 particle counters.

Output
- Analog me[illegible] display
- 0-1V for external strip chart recorder
- 0-5V for autom[illegible] [illegible] acquisition system
- Alarm signal when contamination is greater or less than pre set limits.

Range, particles per second

0-100
0-300
0-1000
0-3000

Calibration

Built-in electro[illegible]

Power

100-240 VAC [illegible] 60 Hz

Size

[illegible]" x 8" x 14"
[illegible] lbs. approx

NOTE

A special cable (AC-1[illegible]) is required for a remote alarm.

For strong acids or caustic solutions, special sapphire windows and shields are available.

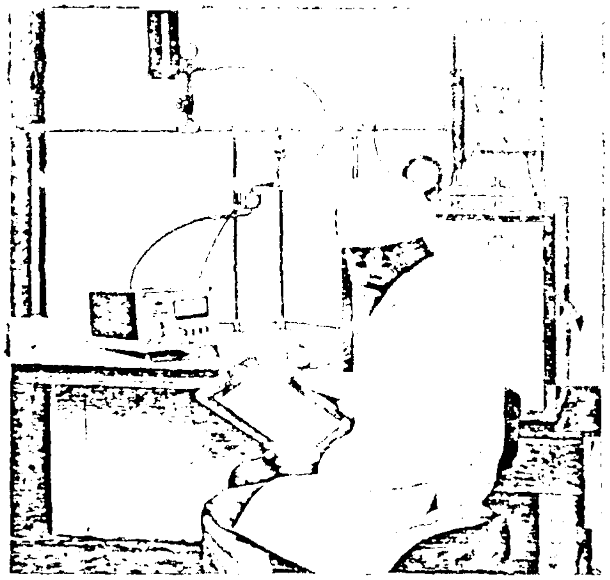
Demonstration units are available at many HIAC Division offices.

[illegible]

*A	1	Sensor [illegible]	
	2	[illegible]	
	[illegible]	[illegible]	
	4	[illegible]	
	5	Sensor [illegible]	
*B	1	100-120 [illegible]	
	2	200-240 VAC [illegible]	

Accessories

ITEM	
Recorder [illegible]	
Recorder [illegible]	
Service Kit [illegible]	
Chart Paper, Single Pen [illegible]	
Chart Paper, Dual Pen [illegible]	
Recorder Pens, Black [illegible]	
Additional Sensor, 2-60 micrometers	[illegible]
Additional Sensor, 3-90 micrometers	[illegible]
Additional Sensor, 4-120 micrometers	[illegible]
Additional Sensor, [illegible]-150 micrometers	[illegible]
Additional Sensor, [illegible] micrometers	[illegible]
Spares Kit [illegible]	[illegible]
Sensor Mounting Stand	[illegible]
Additional Straight [illegible] Sensor [illegible]	[illegible]
Be[illegible] max [illegible]	
Extra [illegible] Sensor [illegible]	
[illegible]	



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Pacific Scientific Company

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4719 West Brooks Street, Montclair, California 91763

Pacific Scientific International

22[illegible] Finchley Road
London N.W. 3

NAEC-92-[illegible]

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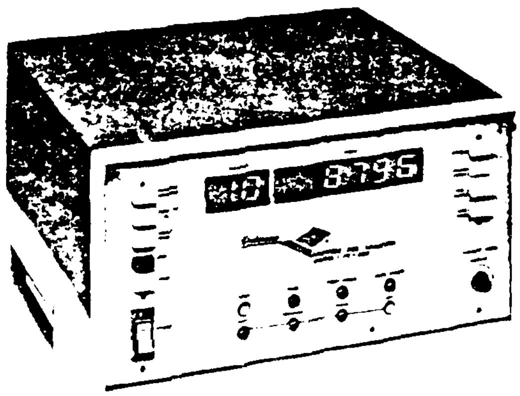
[illegible] WEST BROOKS STREET
MONTCLAIR, CALIFORNIA [illegible]
PACIFIC SCIENTIFIC INTERNATIONAL
HAUPTSTRASSE 132
CH-4450 SISSACH SWITZERLAND

Bulletin 7633

PC-320 SERIES "CRITERION"
LAB or FACTORY USE

"CRITERION", MODEL PC 320 PARTICLE COUNTING AND SIZING ANALYSIS SYSTEM



EXCLUSIVE FEATURES

- Designed to be the nucleus of an integrated particle analysis system
- Six full channels may be expanded to nine or even twelve channels
- "Direct Dial" size thresholds
- Full range calibration in every channel
- Six digit display with built-in timer
- Sample may be defined by volume, time, or pre-set particle count
- All solid state construction including photo detector
- Samples may be run wet or dry with no electrolyte needed
- Data is available in print out form if required
- Total/Delta operation with the flip of a switch.

The PC 320 "Criterion" particle size analyzer is the most advanced instrument of its type available on todays market.

It not only measures particles by size and counts them (in as many as twelve different size groups) but does it all automatically.

The PC 320 will operate with full efficiency on liquids of different optical density and color without any special adjustment. In addition it has an integral indicator which warns of any change in sensor operation due to partial [illegible] flow blockage or change in the fluid system.

The Criterion analyzer has a BCD output which will interconnect with data processing equipment or for analog accessories.

Sensors are compact (2" x 2" x 5") with ultra linear calibration. Sensors can be located as far as 1000 feet from the counter if necessary. In addition, multiple sensors with selector switch can be used. Special sensors for use with corrosive liquids are also available.

In addition to these features the Model PC 320 is suited to either sample bottle or on stream analysis. Every unit is factory calibrated and electronic and reference standards are available.

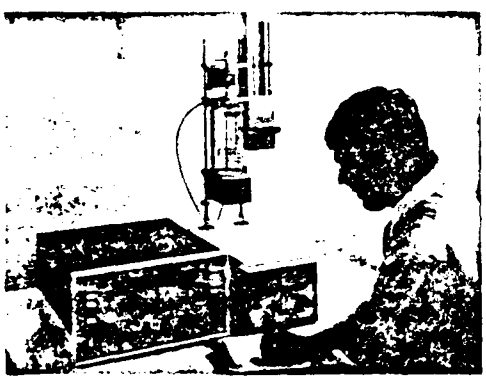
Particles from 1 to 9000 microns can be accurately counted and sized with the proper sensor. Circuits are of modular construction for easy plug-in replacement or service.

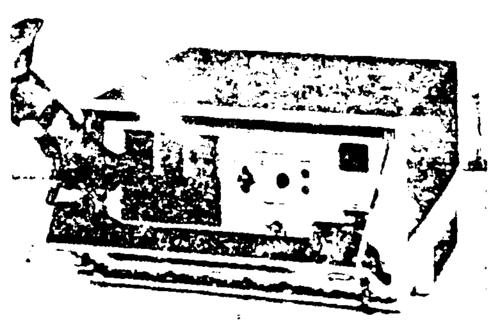
LABORATORY PC-320 SERIES "CRITERION"

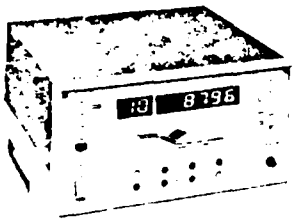
PC 32 [illegible]	[illegible]	[illegible]
	A B C D	[illegible]
*A	1	[illegible]
	2	[illegible]
	3	[illegible]
	4	[illegible]
*B	1	With Sample Timer
	2	With Sample Timer and Recycle Timer
*C	1	100-125 VAC, 50/60 Hz
	2	200-250 VAC, 50/60 Hz
*D	1	CMB [illegible] micrometer sizing capacity)
	2	CMB [illegible] 5-90 micrometer sizing capacity)
	3	CMB [illegible] 2-120 micrometer sizing capacity)
	4	CMB [illegible] 2.5-150 micrometer sizing capacity)
	5	[illegible] 5-300 micrometer sizing capacity)
	6	CMB [illegible] 10-600 micrometer sizing capacity)
	7	E 20 (20-1000 micrometer sizing capacity)
	8	E 45 (45-2500 micrometer sizing capacity)
	9	E 150 (150-9000 micrometer sizing capacity)
	X	With CMH Sensor (specify size)

ACCESSORIES

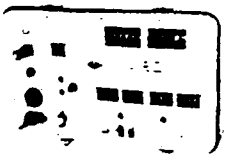
Item	[illegible]
Additional Standard Sensors	CMB [illegible]
Additional Standard Sensors	CMB [illegible]
Additional Standard Sensors	E 20, 45, 150
[illegible]	[illegible]
High Concentration Sensors	CMH [illegible]
AC [illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Printout System	[illegible]
Sensor Selector Switch	[illegible]
Sensor Selector Switch	[illegible]
Sensor Selector Switch	[illegible]
Sensor Selector Switch	[illegible]
Sensor Selector Switch	[illegible]







BASIC HIAC INSTRUMENTS

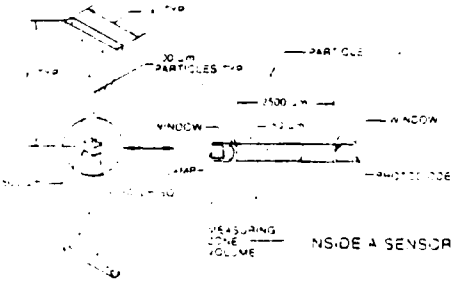


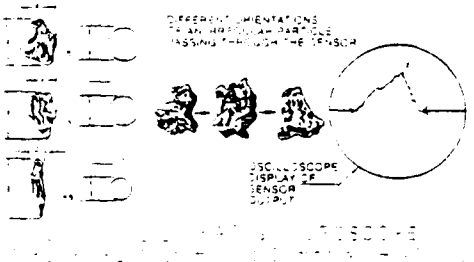
HIAC instruments categorize particles suspended in a carrier medium held in sample containers or flowing in an on-stream system by size and number. They are categorized in from one to six size ranges, with an optional capability of up to twelve channels. These ranges are selected by the operator. Particles are measured accurately regardless of their makeup, size or color characteristics. The instruments count very rapidly, approximately 4,000 particles per second, and can analyze particles per fluid volume or size distribution alone.

Liquid containing the particles to be measured is passed through a sensor where the particles' size and number are sensed and sent along a cable to the counter to be displayed. Each sensor has a size measurement ratio of 1:60 from smallest to largest particle. Therefore, a 1 through 60 micrometre sensor can measure particles from 1 to 60 micrometres; a 2.5 through 150 micrometre sensor from 2.5 to 150 micrometres. The instrument operator programs the display channels for any size distribution within the capability of any one sensor. For example using a 2.5–150 Sensor the operator could select the following size distribution:

Channel	1	2	3	4	5	6
Size	2.5-10µm	10-25µm	25-50µm	50-100µm	100-125µm	>125µm

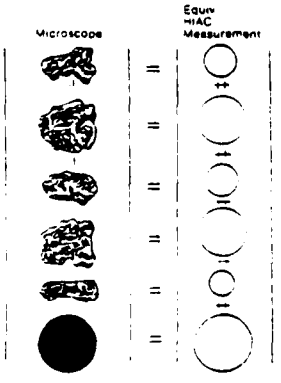
HIAC instruments operate on the principle of light blockage. A constant output from the photodiode is maintained by passing a light through a passageway on to a photodiode. As a particle passes an amount of light proportional to its size is blocked. If recommended concentration levels are not exceeded, 4,000 particles seconds there is only one particle in every ten measuring zone volumes so that each particle is sized individually.





HIAC measures the maximum area of the particle exposed as it passes through the measuring zone.

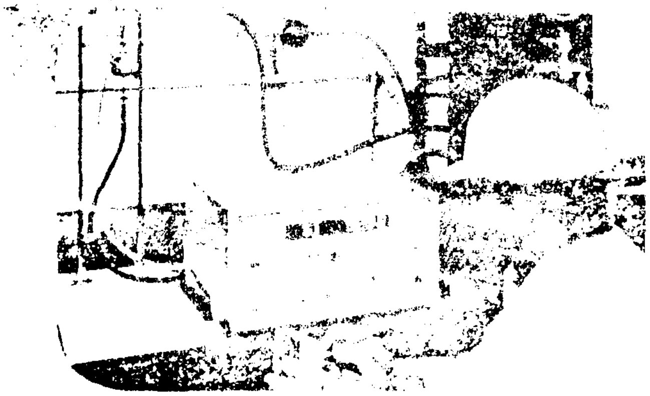
The area is equated to spheres in the HIAC calibration tables for a single dimensional reference.



As you can see, the microscope measures all these particles as being the same, whereas the HIAC measures them as being different by the ratio of their areas. The HIAC method gives more information about the particle and is certainly a more realistic approach to measuring the actual size of the particle.

The operator places the bottle sample to be analyzed into the sample holding cylinder. The analysis is initiated by pushing the [illegible] start button. Filtered air is automatically pumped into the holding cylinder and forces the sample through the sensor and into a metering device which stops the test when the desired [illegible] has been analyzed. The sensor [illegible] counted and sized the particles and the analysis results appear at the test conclusion on the automatic particle counter display. Typical test time, one minute.

The in-stream sampler is attached to the flow line to be tested. The pressure from this line is used to force the liquid through the sensor and in-line fittings with flow meter. The operator sets the flow meter to a given flow rate and pushes the reset button on the counter. This starts [illegible] timing and analysis. At the end of that time, the analysis results are displayed on the counter.



The operator attaches the in-line system with flow controller by means of quick disconnects to the equipment to be tested. The pressure from the system forces liquid through the sampler at approximately 500 cc/min. Of that 50 cc/min. is directed through the sensor (located on the back of the sampler). This flow rate is adjusted by the operator using the flow control adjustment in conjunction with the Delta P gage. The reset button on the counter is pressed and a one-minute analysis begins. At the conclusion the numbers are recorded and the quick disconnects removed.

Automatic Hydraulics • Film Emulsions • Parenteral Solutions • Hypodermic Syringes, Vials and Ampules • Rubber Stoppers and Closures • Manufactured Petroleum Products • Hydraulic Fluids • Micro-Circuits Manufacturing • Missile Systems • Fuel Systems • Hydraulic Test Stands • Trucks, Tractors, Hydraulic Systems • Synthetic Fibers • Nickel Plating Baths • Deionized Water • Construction Vehicles Hydraulic Systems • Magnetic Memory Hydraulic Systems • Pumps and Valves • Turbine Bearings • Aircraft Engines • EHC Fluids • Freon Flush Solvents • Jet Engine Fuel • NC Machinery Hydraulic Systems.

Size Control Of

Dental Polymers • Latex Foams • Titanium Dioxide Paint & White Wall Tires • Dye Stuff Manufacturing.

Seed and Spore • Rust Nodules (salt water corrosion research) • Algae • Nuclear Fuel Granules • Oyster Spat • Shrimp Spawn • Powders

Parenteral Solutions • Foods & Beverages • Manufactured Silicon Oils

Monitoring D.I. Water and Solvents • Cancer Cell Studies • Oil/Water Separation Research • Filter Test Evaluation • Corporeal Blood Filter Evaluation

(1) No electrolyte or special sample preparation necessary
(2) Light blockage principle
(3) Built-in Timer
(4) Manual or automatic control, remote or local.
(5) Indicator lamps
(6) Total solid state construction including photo detector.

a) Printout system
b) Calibration kit
c) Sensor selector switch
d) Spares kits

An automatic system for counting and sizing particles in fluids with a memory to store 1, 4 or 12 channels of information and with a single or tight display

A. For CMB Series Sensors
B. For CMH Series Sensors

A. BNC: For 0-1V base level sensor analogue
B. Sensor: For sensor
C. ABS: Automatic Bottle Sampler
D. Lamp Voltage: For lamp adjustments, replacement
E. Printout: 1-2-4-8 BCD for Printer or TTL Logic Circuitry
F. Accessories: (a) Remote Display
(b) Remote on/off
(c) Computer data acquisition
(d) Simultaneous display

Direct dial electronic threshold size adjustment to set each channel anywhere within the size limits of the sensor.

Factory prime calibrated using spherical standards with calibration chart provided.

1-99 seconds

1-99 minutes

OFF, 100, 1K, 10K, 100K

To indicate blockage, lamp malfunctions, optical density changes.

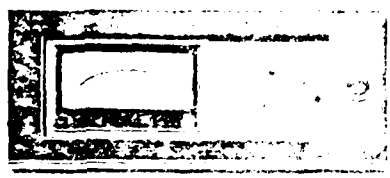
115/230 VAC ± 10%, 47-63 HZ, 40 Watts

Size: 18"W x 9½"H x 18"D
Weight: 40 lbs.

HIAC INSTRUMENTS DIVISION
Pacific Scientific Company

P. O. Box 3007 • 4719 W. Brooks St.
Montclair, California 91763
Telephone: (714) 621-3965

L&N MICROTRAC
Suspended-Solids Monitor (SSM)



- For accurate continuous monitoring of the true concentration of suspended solids in a liquid stream
- Independent of color and particle size
- Direct readout in parts per million
- No calibration material required. Calibration can be checked against standard lab procedure on real samples
- Output signals for process control, recording or alarm
- Designed for high reliability in rugged environments
- Remote, unattended operation . . . low maintenance requirements
- Optional particle-size output (Volume Mean Diameter)

APPLICATIONS

OPERATION

A liquid stream to be monitored is passed through an integral sample cell which is illuminated by a continuous laser source. Suspended solids in the stream scatter light as they pass through the cell; the scattered light is directed by a lens which focuses the light on a proprietary Compumask™ optical filter. The optical filter passes a selected portion of the light which is then focused by another lens onto a photodetector.

The light received by the detector is proportional to the volume of particles in the liquid stream. The instrument automatically corrects for the attenuation of the laser due to light scattering and normalizes the output signal to the incident intensity. These automatic corrections permit reading a true linear volume response independent of light absorption by the host liquid.

Initial operation is extremely simple. A zero adjustment is made with clean water flowing through the cell. The sample stream is then switched to the instrument which continuously measures the amount of suspended solids.

A one-time single-point calibration using gravimetric data taken on a process sample from the instrument output is used to adjust for true mass loading. Routine operation consists of checking the zero with clean water (usually once a day) and cleaning the sample cell with the plunger provided (usually once a week). Cell cleaning and zero adjustment are both accomplished without entry into the instrument and take only a few minutes to accomplish.

Compared to other monitoring techniques, the SSM offers significant advantages, including:

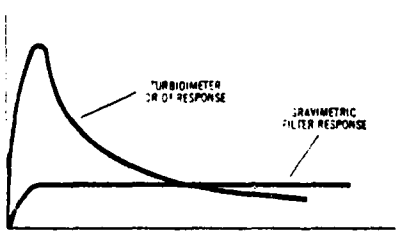
- Direct measurement of volumetric concentration or mass loading after a single one-point calibration.
- Linear dynamic response, independent of particle size, in the suspended-solids range.
- True continuous analog of the gravimetric method, avoiding the inconsistent relationships between turbidity and suspended solids.
- No routine calibration — only an occasional zero check required.
- Optional output signal representing average particle size can be provided, often useful in checking performance of control or process equipment.
- Automatic compensation for variations in transmission unaffected by color of liquid.

TURBIDITY AND SUSPENDED SOLIDS

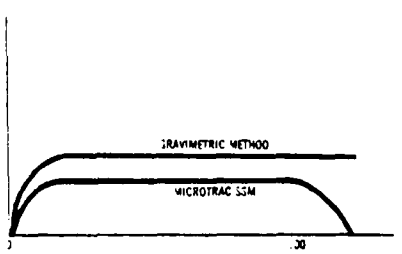
These two measurements are widely used in water and waste-water processes. Turbidity is related to the visual clarity of a sample and depends upon the cross-sectional area of the particles, the concentration of particles, and the color of the host liquid. Suspended solids is a measurement of particle concentration in the range between colloidal and settleable solids. The measurement is referenced against the gravimetric filtration method and must therefore be independent of size distribution over this range.

Prior to the introduction of a true suspended-solids monitor, turbidimeters were employed to imply suspended solids, sometimes having scales marked in parts per million. The relationship between turbidity and true suspended solids is consistent only if particle-size distribution and host liquid color are constant and if colloidal particles are low in concentration compared to the suspended solids level.

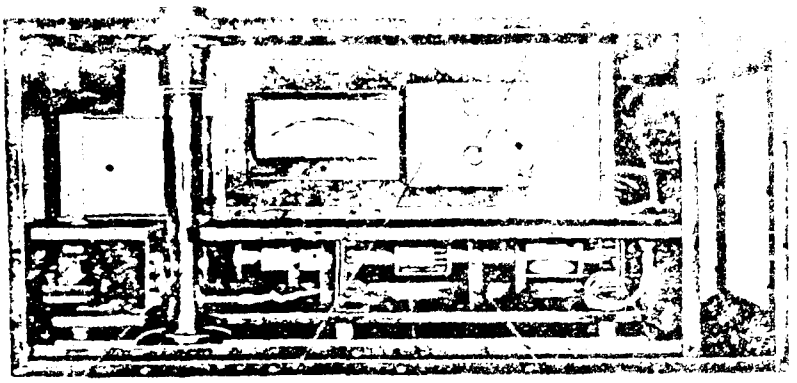
Turbidity and suspended solids are each useful but are measurements with different uses and correlation between them should not be attempted.



This figure illustrates the response of a turbidity (particle-areal) instrument with constant loading and variable particle size. While differing in level, this general response is obtained whether the turbidimeter uses back-scatter, forward-scatter or 90° scatter nephelometer.



This figure illustrates the similarity of the Microtrac SSM volume 90° response to the gravimetric method. After a single-point calibration these curves would be going near over a range of about 100 microns.



SPECIFICATIONS

Concentration Range

Particle-Size Range

Sensitivity

Accuracy

Precision

Ambient Temperature Range

Sample Temperature Range

Typical Flow Rate

Output Signals

Controls

Indicators

Power Requirements

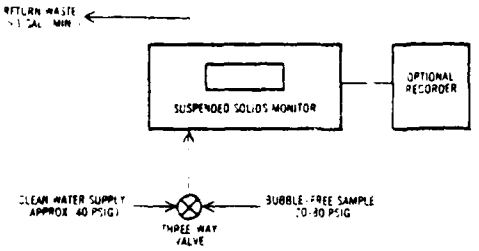
Enclosure

Weight

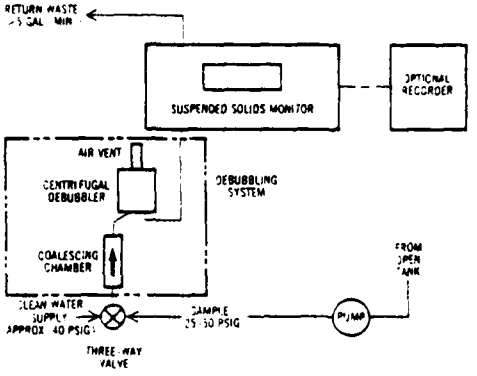
OPTIONS AVAILABLE

Leeds & Northrup

Typical Plumbing Connections for Microtrac SSM



Without Debubbling System



With Debubbling System

Also available

7991 MICROTRAC Particle-Size Analyzer

for particle-size analysis in the laboratory

- Designed for plant and quality-control lab analysis
- Available for wet slurries and dry powders suspended in water (with optional alcohol) to measure dry powders in air
- Particle-size range: 1.8 to 176 or 3.8 to 300 microns
- On-line optical system, sample cell and processing electronics offering the following features:
  - 13-channel histogram output via integral digital printer
  - Operator independent, insensitive to sample concentration or density, factory calibrated
  - Summary data on size distribution and surface area
  - Repeat analyses every 3 to 300 seconds, new sample every 2 minutes

Ask for Data Sheet 04-7124-TP

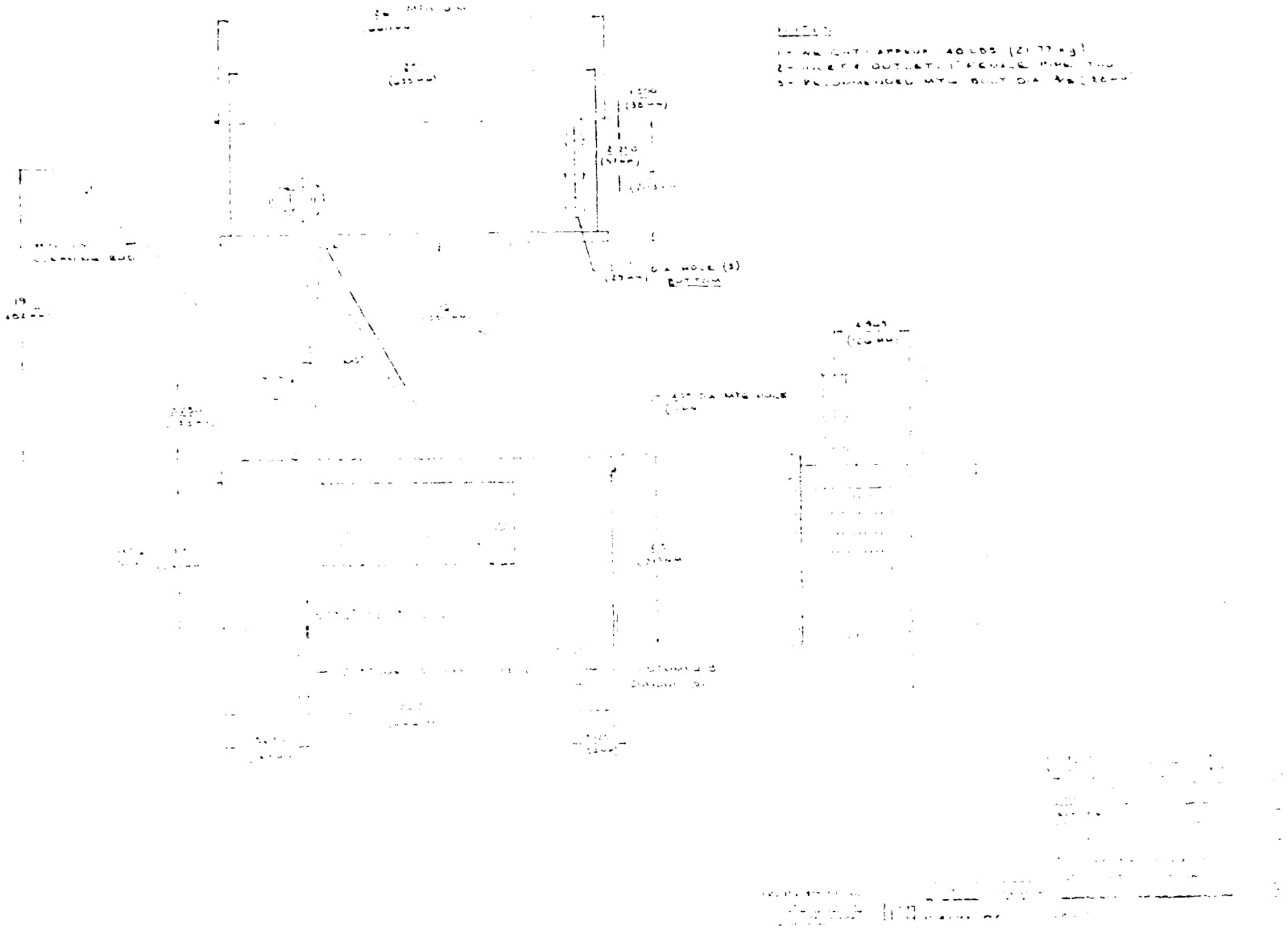
7981 MICROTRAC Particle-Size Monitor

- Designed for on-line, real-time process monitoring and control
- Available in two standard configurations: wet slurry or dry powder
- Uses same optical system, sample cell and processing electronics as Microtrac Analyzer, plus:
  - On-line sample-conditioning system
  - Digital or analog outputs with local digital display
  - Rugged NEMA 12 industrial enclosure
  - Internal security system to permit remote, unattended operation
- Provides same data output forms as the 7991 Microtrac Analyzer (digital or analog), plus any three customer-specified percent-passing channels, analog current outputs or printer (optional)
- Usable on-line in process monitoring or off-line in routine analysis

Ask for Data Sheets 04-7122-TP and 04-7126-TP

Questions about applications should be directed to the Advanced Business Development Department, Leeds & Northrup Company, North Wales, PA 19454

LEEDS & NORTHRUP North Wales, PA 19454



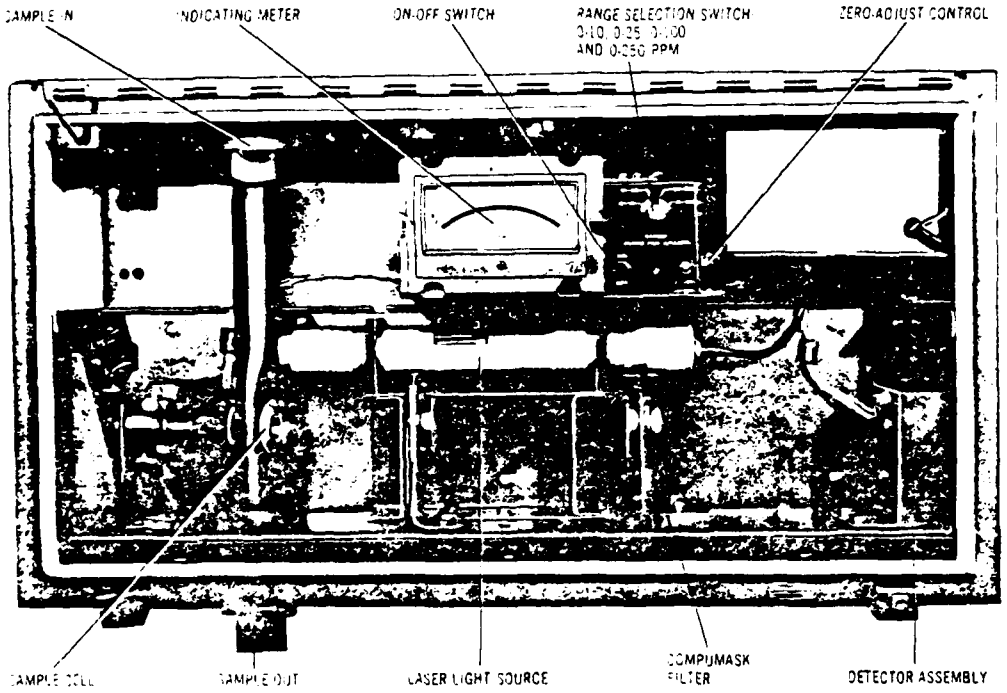


Figure 9: Interior of Suspended Solids Monitor

LEEDS & NORTHRUP COMPANY Dickerson Road • North Wales, Penna. 19454

MICROTRAC™ Suspended Solids Monitor - Abbreviated Price List

Sales Work Sheet

CATALOG NUMBER

7982

Load Range
- ☐ 1. 0-250 ppm ☐ $3880 (-10) Delivery 8 weeks
- ☐ 2. 0-2000 ppm ☐ $3880 (-20) Delivery 8 weeks

Sample Cell Materials
- ☐ 1. Brass/Copper ☐ Standard (-10)
- ☐ *2. Stainless Steel ☐ $300 (-20) Add 1 week

Window Materials
- ☐ 1. Optical Crown Glass (0° -60°C) ☐ Standard (-10)
- ☐ *2. Fused Silica (Hi Temperature) (0° - 120°C) ☐ $370 (-20) Add 2 weeks
- *3. Sapphire (Hi Abrasion) ☐ $240 (-30) Add 2 weeks

Sample Conditioning None ☐ (-00)
- ☐ *1. Debubbler Std Mtl ☐ $450 (-10) SS ☐ $750 (-11)
- ☐ *2. External Sample Pump Cast Iron ☐ $450 SS ☐ $1150
- *3. Laboratory Sample Conditioner ☐ $3950 (-40) Add 2 weeks

Size Measurement None ☐ (-00)
- ☐ *1. Mean Volume Diameter. 0-10V, 0-100mV Output ☐ $660 (-10)

Display
- ☐ 1. Analog Meter ☐ Standard (-10)
- ☐ *2. Digital Meter ☐ $180 (-20)
- *3. Remote Meters (Analog or Digital) See Catalog

Remote Outputs
- ☐ *1. Non-isolated analog current and voltage (internal) 4-20 mA, 1-5V ☐ $60 (-00)
- ☐ *2. Isolated Analog Current (separate package) See Cat. ☐ $150 (-20) Add 2 weeks
- 3. Recorder outputs 0-10V, 0-100 mV ☐ Standard (-00)

Remote Alarms
- ☐ 1. Remote Window Service Indicator Output ☐ Standard (-00)
- ☐ *2. Alarms, Indicators and Controls. See Catalog

Controls
- ☐ 1. Remote Manual Zero Adjust Inout ☐ Standard (-00)
- ☐ *2. Remote Range Selection ☐ $55 (-10)
- *3. Automatic Zero Adjust. See Catalog

Line Connection
- ☐ *1. 6-foot Line Cord and Plug 120V, 60Hz ☐ $15 (-66)
- ☐ 2. Conduit Entry, 120V, 60Hz ☐ Standard (-16) 220-60 ☐ (-26) 120-50 ☐ (-15) 220-50 ☐ (-25)

Mounting Provisions
- ☐ 1. Wall Mount ☐ Standard (-10)
- ☐ *2. Bench Mount ☐ $100 (-20) Add 2 weeks
- *3. Floor Stand ☐ $100 (-30) Add 2 weeks

☐ Mounting Spares – ☐ None (-00) Recommended Spares (See Catalog).

* Available at additional cost. See Catalog for other options. Prices as of Dec. 1, 1978 are subject to change without notice.

TELEPHONE 215 643-2000 • CABLE ADDRESS LEEDSNORTH

NAEC-92-146

MICRO PURE SYSTEMS INC.

Monitoring Contaminants
in Closed Systems

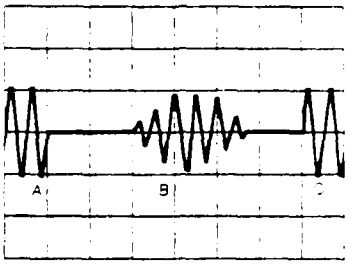
The Versatile System

Due to the nature of ultrasonics and the unique design of our discriminator and chamber, the Micro Pure system can be used for the monitoring of most liquids. The system operates independently of the fluid's thermal or electrical conductivity, viscosity or optical properties. Included are: Water, oil, latex, acids, dyes, inks, paints, hexane and a variety of food stuffs. These applications would apply to the chemical, food, photographic, waste water, hydraulic and pharmaceutical industries as well as the manufacturing of integrated circuits and printing inks.

The Operating Principle

The micro-contaminant monitor, Model 1100, uses ultrasonic wave reflection to detect microscopic particles and bubbles in a flowing liquid. This is accomplished by the use of two separate components, an in-process flow-through ultrasonic chamber and a pulser-receiver module or monitor.

A piezo-electric transducer element mounted in a chamber external to the fluid flow, receives electrical pulses from the MCM-1100 and converts them into acoustic waves. These waves are focused and passed into the flowing stream. Particles or bubbles in the liquid will reflect sound back to the transducer where the sound is reconverted to an electrical signal. This signal is then coupled to the receiver module.

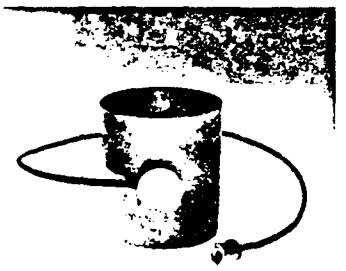


Oscillogram — A-Source wave from transducer; B-Reflection from contaminant; C-Reflection from chamber wall

The MCM-1100 amplifies and converts the return signal into a series of digital impulses which are processed to determine the size and number of contaminants measured. A separate logic function discriminates between microparticles and microbubbles above 50 microns.

The Chamber

One of the most [illegible] of the Micro Pure [illegible] process capable [illegible] chamber design [illegible] the fluid, [illegible] user the advantage [illegible] real-time monitoring. The need [illegible] random sampling and [illegible] tory analysis is eliminated. This inspection technique allows the monitoring of relative solid content [illegible] as well as the degree to which a chemical reaction has progressed.

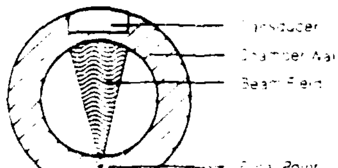


Steel chamber

The fact that the transducer element does not directly contact the monitored fluid and that the chamber material can be matched to the process [illegible] inspection system [illegible] contaminant levels. The chamber can be adapted to [illegible] and toward [illegible] modifications are used to [illegible] system performance or [illegible] tion requirements. Some examples of chamber materials: glass, stainless steel, aluminum, polystyrene and [illegible].

The Pulser-Receiver Modules

[illegible]



[illegible]

The People Behind the Technology

Leigh R. Abts

Mr. Abts had served as Bio-Medical Engineer for the Department of Cardiovascular Surgery at Rhode Island Hospital since 1973. A member of the Acoustical Society of America and Sigma Xi, he has numerous publications in the field of ultrasonic detection of microparticles and microbubbles. He has served as a consultant to many major manufacturers of blood oxygenator devices. His investigation in the field of extracorporeal monitoring for microemboli led to his developing the patented technique used in the ultrasonic measurement of particles in flowing liquids.

Presently Mr. Abts serves as President of Micro Pure Systems and is actively involved in the further development of our technology.

Robert T. Beyer, Ph.D.

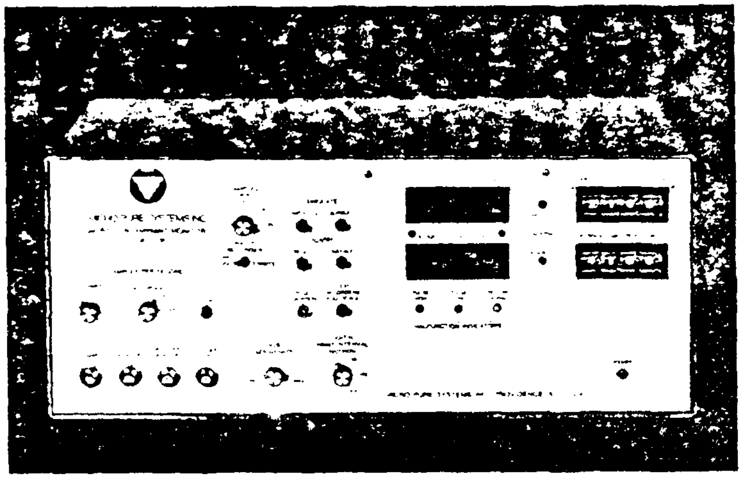
Professor Beyer has been a member of the Physics Department of Brown University since 1945 and served as its Chairman between 1968-74. He holds two U.S. patents, is the author of several books and over one hundred articles principally in the field of ultrasonics. He has supervised 20 Ph.D. theses in this field. In 1968-69 he served as President of the Acoustical Society of America and is currently Chairman of the International Commission on Acoustics. He has been an advisor to the Micro Pure Research Program since 1974 and is a member of the Board of Directors.

Karl E. Karlson, M.D., Ph.D.

Dr. Karlson has been a member of the staff at Rhode Island Hospital since 1971 and now serves as Surgeon-in-Charge, Division of Cardiovascular and Thoracic Surgery. He has had teaching appointments at three universities. Currently he is Professor of Medical Sciences at Brown University and Adjunct Professor of Biomedical Engineering at the University of Rhode Island.

He has had an interest in extracorporeal circulation for many years, particularly with the function of blood oxygenators and the production of microemboli by these devices. His interest in this field provided the impetus for the development of the ultrasonic methods of detection employed by Micro Pure.

In August 1979 he was the U.S. representative in cardiovascular surgery for a National Council for U.S.-China trade delegation to the Peoples Republic of China. Presently Dr. Karlson serves as Chairman of the Board of Micro Pure Systems, Inc.



The MCM-1100

Manufacturer's Specifications for Model 1100 Micro-Contaminant Monitor

PULSER: Spike type output with minimum of 300 negative volts into 50 ohms impedance. Width at half amplitude points of spike may vary from [illegible] nanoseconds depending on application.
RECEIVER: Broadband with a low signal to noise ratio and fast recovery from overload. Bandpass nominally 3 to 12 MHz.

Controls:
SAMPLES PER SECOND [illegible]
VIEW [illegible]
SAMPLES PER DISPLAY [illegible]
RESET COUNTERS: In the COUNT mode of operation the counters may be reset to zero by use of this push button control.

TEST RECORDERS FULL SCALE: This push button allows for testing both the analog outputs and the digital printer. The printer should read +9999 and +9999.
DIGITAL PRINT INTERVAL: Print intervals of 1, 10, 60, 600 seconds may be selected.
ALARM RESET: This push button [illegible] the alarm and must be pressed when the instrument is first turned on.
ALARM DISABLE: [illegible]
SIMULATE PARTICLES & BUBBLES [illegible]
SIZE SENSITIVITY [illegible] Positions A, B and C are [illegible] controls and [illegible] allows a rear panel 10 turn vernier to be used.

PARTICLE AND [illegible]
ANAL[illegible] RANGE [illegible]

Indicators and Outputs
BUBBLE AND PART[illegible]
PULSE [illegible]
NO SIGNAL RETURN [illegible] in sample chamber [illegible] is lighted [illegible]
OUTPUT TO CHAMBER [illegible] as well as an output [illegible] chamber.
OUTPUT MONITOR [illegible] 20 dB.
RECEIVER MONITOR [illegible]
TRIGGER OUTPUT [illegible]
ANALOG OUTPUTS [illegible]
DIGITAL PRINTER [illegible]

[illegible]

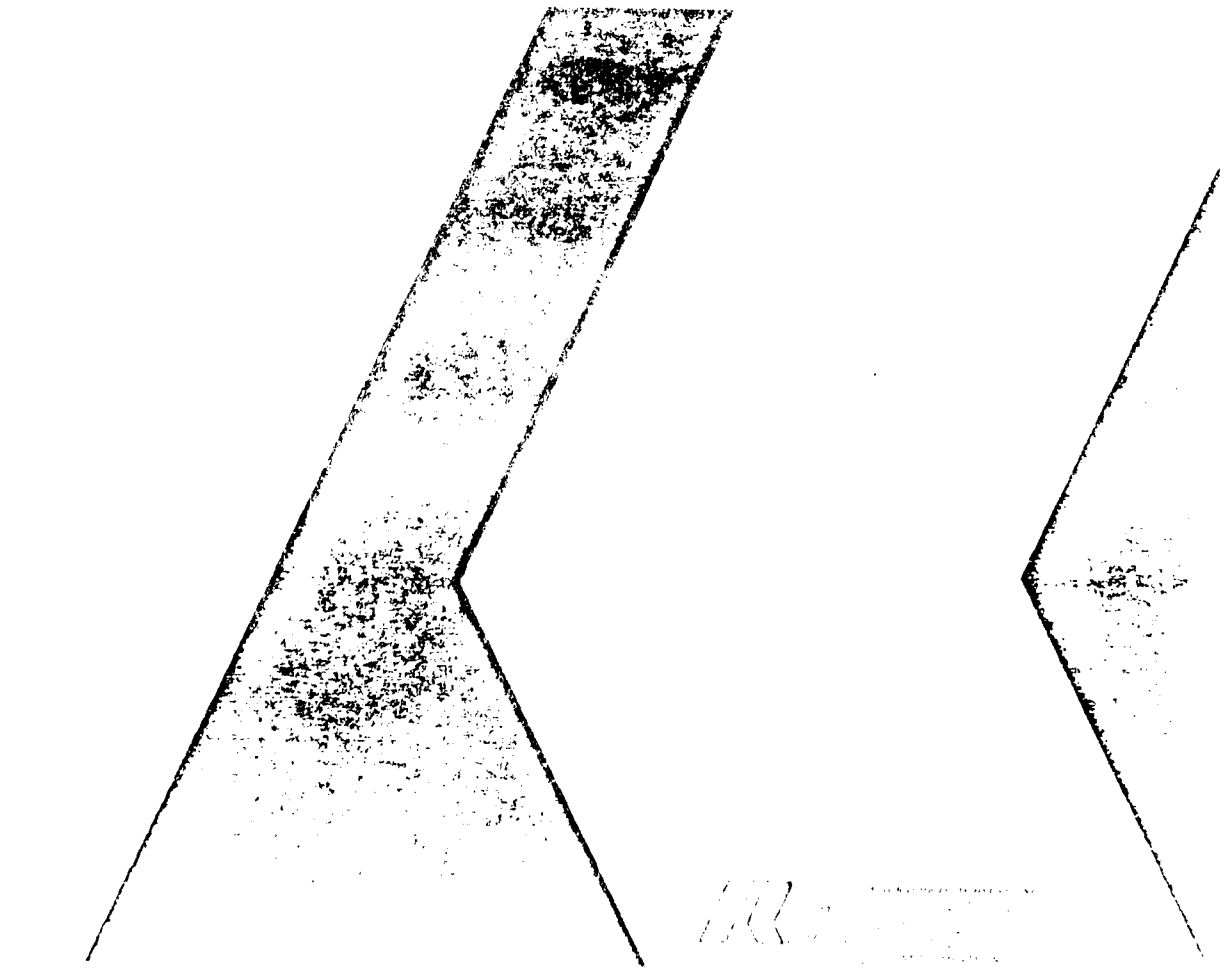
A Breakthrough in Technology.

Micro Pure Systems, Inc. introduces a new era in the monitoring of micro-contaminants in fluids. The employment of new techniques in focused ultrasound has led to the development of a patented system for the in process detection of particles and bubbles below 1 micron in diameter. Discrimination between microsolids and microbubbles is achievable down to 50 microns.

This innovative technology is the culmination of years of research by an outstanding team of engineers, physicists and physicians at Brown University and Rhode Island Hospital. The MCM-1100, featured here, evolved through an effort to monitor gaseous and particulate contaminants in the heart-lung bypass circuit utilized in open heart surgery.

The combination of the research and development endeavors of the scientists at Micro Pure with our high quality of manufacturing, has resulted in products of high integrity. As a result of its adaptability and capacity, the range of applications is substantial. The MCM-1100 is the most reliable, accurate and versatile micro-contaminant monitor available today.

Micro Pure is interacting with numerous Fortune 500 companies and is actively engaged in responding to their quality control needs. Micro Pure's scope of activity and dedication to your quality control functions will assure the success of your efforts to maximize product reliability.



[illegible]YCO TOTAL CAPABILITY IN PARTICLE COUNTING [illegible]GY

THE CAPABILITY

[illegible] systems and instrumentation for every [illegible] counting [illegible] particles [illegible] is [illegible] automatic particle measuring equipment is [illegible] clean rooms, com[illegible] hygiene, process control, air [illegible]

THE FACILITY

[illegible] headquarters are located in the heart of the San [illegible] community. The complex covers 27,500 [illegible] and houses the manufacturing, administrative, scientific and [illegible] equipped laboratories for the study of indus[illegible] processes that involve detection and measurement [illegible] liquids and gases.

[illegible] permits Roy[illegible] engineers [illegible] scientists [illegible]

THE TECHNOLOGY

[illegible] gaseous or liquid suspension scatter and/or absorb light in [illegible] that vary with their size and concentration. This light-scattering [illegible] in suspension to be detected, measured and [illegible] size and concentration data by optical systems developed [illegible] purpose.

[illegible] particle size concentration measurement tech[illegible] a broad spectrum of applications in [illegible]

[illegible] particle suspensions and the [illegible] measurement of particle size and [illegible] were [illegible] instruments, Inc. Par[illegible] features several optical systems [illegible] them. These include [illegible] Right Angle Scatter [illegible] atmospheric suspen[illegible] Near Forward Scatter [illegible] particles in atmospheric [illegible] Light Absorption Total Scatter systems for measuring par[illegible]

[illegible] particles in a flow of gas or liquid [illegible] impulses [illegible]

[illegible] where [illegible] composition of the particles in [illegible] for the Royco instrumentation utilizing the right-[illegible] recommended for maximum size resolution. [illegible] large quantities of ambient gas where particles in sus[illegible] composition, size and optical properties, a [illegible] the near forward scatter optical system will [illegible] best results.

[illegible] analyze particle size and concentration in liquid suspension, a Royco [illegible] based on a light absorption total scatter system will be most effective.

To facilitate and implement the technology of particle counting, Royco has developed and offers the automatic systems, instrumentation and accessories listed on the following pages. In addition to the broad range of standard instruments shown in our catalog, Royco also has the capability for [illegible] instruments for special applications. You are invited to discuss your needs with us at Menlo Park, California, or with your local Royco sales engineer.

INSTRUMENTATION FOR GAS ANALYSIS

[illegible] Right Angle (90°) Optical System as shown in Figure 1 is recommended for maximum particle size resolution.

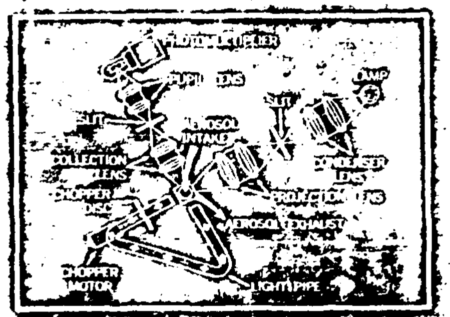


Figure 1: Right Angle (90°) Scatter Optical System

When monitoring large volumes of ambient gases where suspended particles can vary widely in composition, size and optical properties, a **Near Forward Scatter Optical System** as shown in Figure 2 will produce best results.

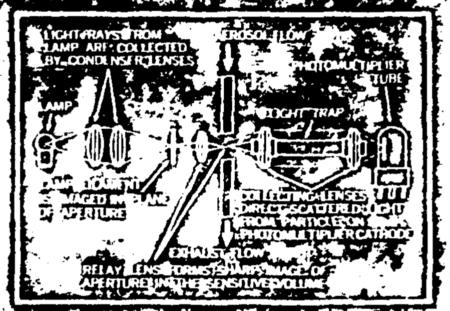


Figure 2: Near Forward Scatter Optical System

SPECIFICATIONS

SUMMARY OF SPECIFICATIONS — MODEL 203

Optics	[illegible]
Particle Size Sensitivity	[illegible]
Sample Flow Rate	[illegible]
Particle Concentration	[illegible]
Readout	[illegible] See Table [illegible] listing
Calibration	[illegible]
Power Requirements	[illegible] watts [illegible]
Environment	[illegible]
Dimensions	Sensor and sample flow controller [illegible] Readout Mounting [illegible]
Weight	Sensor and [illegible] flow controller [illegible] Readout Mounting [illegible]
Mounting	May be [illegible]

SUMMARY OF SPECIFICATIONS—MODEL 220

Optics	Right Angle 90° scatter
Particle Size Sensitivity	0.5 micrometer [illegible] diameter and larger [illegible] 0.3 micrometer sensitivity available on special order
Sample Flow Rate	[illegible] cubic ft per minute
Particle Concentration	Up to [illegible] particles per [illegible] recommended maximum
Readout	[illegible] display [illegible] analog meter [illegible] See Table 1 for listing
Calibration	[illegible] Prime factory calibration [illegible]
Power Requirements	[illegible] watts [illegible]
Environment	Ambient temperature from [illegible] Relative humidity 30% to 85% [illegible]
Dimensions	Sensor and Sample Flow Controller Only [illegible]
Weight	[illegible]
Mounting	May be rack or [illegible] mounted

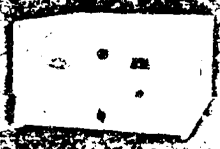
SUMMARY OF SPECIFICATIONS — MODEL 218

Optics	[illegible]
Sensitivity	[illegible] micrometer
Concentration	[illegible] 10,000,000 particles [illegible]
Air Flow Rate	[illegible] cubic feet per minute
Particle Size Ranges	Selectable at 0.[illegible] 2 [illegible] 5 and [illegible] micrometers threshold
Digital Display	[illegible] digits. May be manually held or reset
Sample Time Duration	Selectable [illegible] minute, 10 minutes [illegible] manual
Calibration	[illegible]
Power Options	[illegible] 130 VAC at 50/60 Hz [illegible] NiCad rechargeable [illegible] Battery reserve power for one hour [illegible]
Weight	With case — 26 lbs including battery [illegible]
Dimensions	18 inches (45.7 cm) D × [illegible] inches [illegible] cm) H with case [illegible]

Standard Accessories. A complete family of [illegible] accessories is available for Royco Right Angle (90°) Scatter and Near Forward Scatter [illegible]. Please see Page 7 and 8 for a full listing of available units.

For measurement of airborne particles [illegible] micrometers and larger.

Shown in Photo with optional Model [illegible] 507 Digital Display module [illegible] Printer and mounting cabinet.

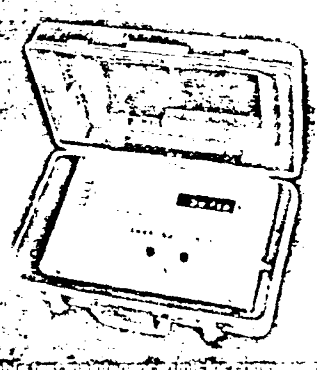


MODEL 220 Multi-Range Particle Counter

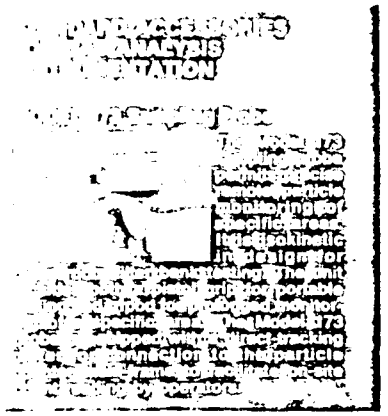
For simultaneous automatic counting for multiple particle size ranges. Shown [illegible] sensor, flow control and power supply. Optional Digital or Analog Display with separate power supply also available. See Table 1 on Page 4 for [illegible].

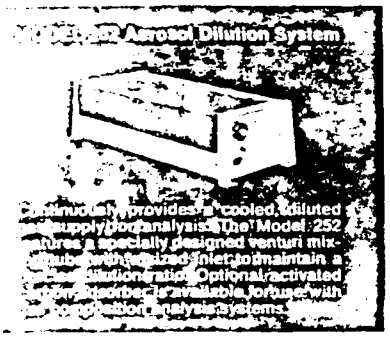
PORTABLE PARTICLE COUNTERS

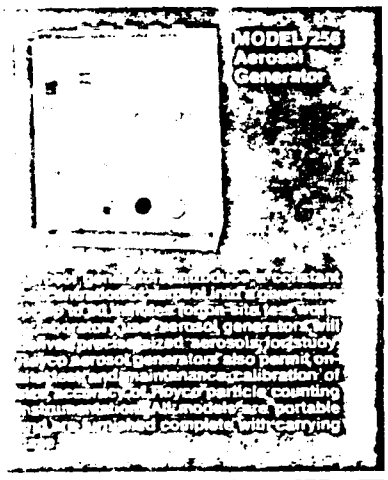
MODEL 218 Multi-Range Counter [illegible] Display; AC/DC Power

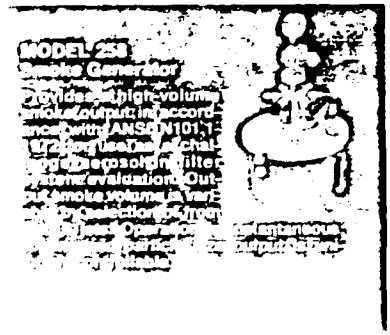


A portable [illegible] maintenance [illegible] automobile emission [illegible] pollution [illegible] AC power [illegible] power pack optional [illegible]









The Standard Accessories listed below are for use with either Royco instrumentation for gas analysis or liquid analysis as indicated. See Page 8 for a complete list of general purpose accessories common to both gas and liquid instrumentation.

SPECIFICATIONS - Standard Accessories for Gas Analysis Instrumentation

MODEL 252 Aerosol Dilution System
Dilution Ratio
Sample Flow Rate
Operating Pressure
Gas Composition Limits
Accessories
Power Requirements
Dimensions
Weight

MODEL 256 Aerosol Generator
Aerosol Output
Operating Period 90 minutes
Particle Size Range
Filter HEPA type
Desiccant
Power Compressed gas at
Controls and Gauges
Dimensions
Weight 28 lbs
Accessory Pumps
Model 13 Output
AC at 50/60 Hz Size
W x 9" (22.9 cm) D
Model 14 Output
AC at 50/60 Hz Size
W x 12" (30.5 cm) D

MODEL 258 Smoke Generator
Undiluted Smoke Output 85 to 510 liters per minute adjustable by the number of jets employed. Concentration of 5 milligrams per cubic liter
Test Smoke Material Dioctyl Phthalate (DOP) is standard. Any liquid can be used if safe.
Power Compressed air or other gas supply to deliver gas at 25 PSI or greater. Air supply connector, air line filter and pressure regulator included.
Controls and Gauges Liquid gauge to monitor liquid level. Thermometer to measure liquid temperature.
Dimensions 18 inches (45.7 cm) H x 12 inches (30.5 cm) W x 12 inches (30.5 cm) D
Weight 25 lbs. (11.34 kg)

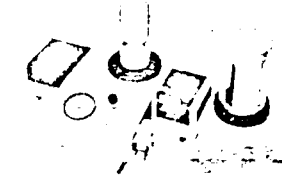
SPECIFICATIONS - Standard Accessories for Liquid Analysis Instrumentation

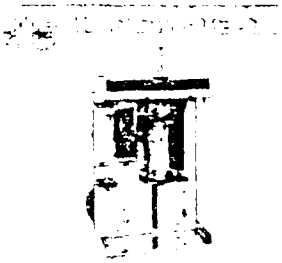
MODEL 363 Liquid Batch Sample Feeder
Sample Size
Sample Flow Rate

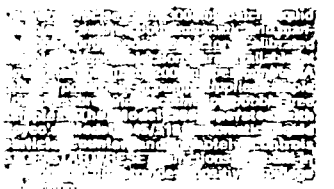
MODEL 366 Volumetric Batch Sample Feeder
Sample Volume
Sample Flow Rate
Viscosity Range
Operating Pressure Max.
Max. Bottle Height
Construction
Power
Dimensions

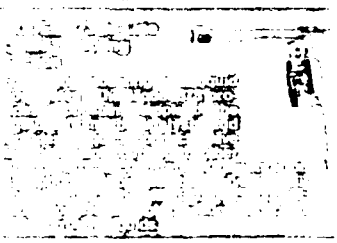
MODEL 373 In-Line Sampling Section
Sample Flow Rate
Operating Pressure
Dimensions

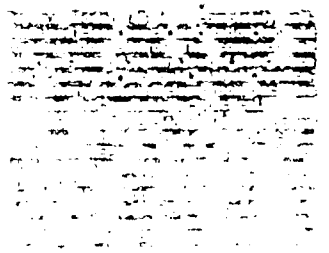
MODEL 146 Contamination Control Center
Dimensions Overall Size
Work Surface Size
Air Circulation
Hydraulic System
Power Requirements
Particle Analyzer
Digital Printer
Batch Sample Feeder











...ERAL PURPOSE ACCESSORIES COMPATIBLE ...ITH ALL ROYCO INSTRUMENTATION

The accessory equipment described on this page is compatible with Royco's full family of particle counting and sizing instrumentation for both gas and liquid analysis.

MODEL 107 Alarm Module

Analog Alarm Module for audible signal and meter reading indication that a pre-set particle count level has been exceeded. Reset and audible cut-off controls are provided. Operates on 115/230 VAC at 50/60 Hz. 6½ inches (16.5 cm) H x 8 inches (20.3 cm) W x 11 inches (27.9 cm) D. Weighs 9 lbs. (4.1 kg).

MODEL 145 Instrument Cart

The Model 145 instrument cart is designed to provide a movable multi-level mounting for Royco particle counting systems. The unit is furnished with 5 AC convenience outlets and full width storage drawer.

MODEL 129 and 129C Digital Printers

Royco's Model 129 digital printers are medium speed, parallel entry units that scan and print out data stored in multi-channel memories. Operation uses reliable inked ribbon and standard paper. **Optional clock (Model 129C) time dates printed data.**

SPECIFICATIONS — Model 129 and 129C Digital Printers

Printing Speed: 2.5 lines per second; 9 characters per line.
Print Format: 8421 BCD format.
Power: 115/230 VAC at 50/60 Hz.
Dimensions: 5½ inches (14.0 cm) H x 7¾ inches (19.1 cm) W x 14½ inches (36.8 cm) D.
Weight: 20 pounds (9.1 kg)

GENERAL INFORMATION

Terms of Sale and Shipment

Royco particle counting instruments and systems are priced F.O.B. Menlo Park, California. All prices are subject to change without notice. Terms are Net 30 days.

Leasing Agreements

Leases with option to purchase are available to meet the specific requirements of each user. You are invited to contact our Menlo Park Headquarters for full details.

Warranty

All Royco products are warranted against defects in materials and workmanship. This warranty applies for 1 year from date of delivery, or in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Royco. No other warranty is expressed or implied. Royco is not liable for consequential damages.

Maintenance and Service

Royco recognizes its responsibility to provide each user with the technical support required to assure the full economic life of each Royco product. Royco service centers provide repair and replacement service to users of Royco equipment both during and after the new equipment warranty period. Each service center maintains a fully trained staff and an inventory of tested replacement parts.

Repair labor and parts are charged at the current catalog rates then in effect for all out-of-warranty service performed at a Royco service center. Field service for on-site repairs will be charged at the current catalog rates in effect for all out-of-warranty repair labor and parts. All travel, meals and lodging will be charged at cost for both in-warranty and out-of-warranty service.

Preventive Maintenance and Calibration Service and Contracts

Routine preventive maintenance and calibration will greatly extend the useful out-of-warranty instrument life. This service is available on a "demand" basis or under service contracts. For detailed information, contact your local Royco Sales office.

FIELD ENGINEERING OFFICES AND SERVICE CENTERS ROYCO U.S.A.

Boston
Telephone: 617/891-5320

Chicago
Telephone: 312/428-7794

Los Angeles
Telephone: 213/257-5340

San Francisco
Telephone: 415/325-7811
Telex: 34-8323

ROYCO INTERNATIONAL

Gelman Hawksley, Ltd.
12 Peter Road
Lancing, Sussex, BN15 8TN, England
Telephone: 2815-6
Telex: 87134

Royco Instruments, Inc.
Dennis Haslop, European Marketing Mgr.
9 Cambridge Rd.
Brighton, Sussex BN3-1DF, England
Telephone: 774238
Telex: 87323 HASLOP

Royco Instruments, Inc.
Uwe Jessen, European Sales Manager
Hertigstrasse 51
7250 Leonberg-2, W. Germany
Telephone: 07152/47375

Beckman Instruments, Lapso Division
P.O. Box 3100
Fullerton, California 92634 U.S.A.

London Industries, Ltd.
1c-13 Higashi-Minemachi
Ohta-Ku, Tokyo, Japan
Telephone: 404/8781-5
Telex: 0242-3320

A SUBSIDIARY OF HYCEL, INC
ROYCO INSTRUMENTS, INC

141 Jefferson Drive
Menlo Park, California U.S.A. 94025
Telephone: 415/325-7811 • Telex: 34-8323

SPECTREX CORPORATION

PROTOTRON PARTICLE COUNTER MODEL ILI 1000

FEATURES

- Makes in-situ, quantitative particle counts of bottled liquids
- Reads any bottle with a 20 to 200 mm inside diameter
- Uses scanning laser beam with all solid state electronics
- Provides automatic digital readout after a scan of 10 cc in approximately 15 seconds
- Detects the number of particles above a manually set threshold between 1 and 100 μm
- Can be used to count particles in liquids flowing through transparent pipes

APPLICATIONS

- Quality control of hydraulic fluids & oils
- Particle count of air filters
- Monitoring continuous flow operations through glass pipe
- Inspection of pharmaceutical solutions
- Water quality testing for semiconductor industry
- Quality control for bottled beverages

.... and many other applications.

GENERAL DESCRIPTION

The standard Prototron Particle Counter includes both diffuse vertical illumination for visual identification of large particulates, and a scanning laser beam for detection of small particulate matter.

The 31 pound, compact unit (12" X 24" X 18") houses the laser tube, scanner and photo detection electronics. A front panel knob allows setting of a particle size threshold limit between 1 and 100 μm. Particle counting and illumination are controlled by front panel pushbuttons. A simplified schematic of the instrument is shown in Figure 1. The laser beam focuses inside the bottle in a 2 cm long "sensitive zone" as shown in Figure 2.

The secondary lens picks up scattered light (in the annulus around the target) from all particles in the path of the scanning laser beam. However, the photo detection electronics only registers those particles in the "sensitive zone", which are larger than the size specified by the threshold setting. Usually, dust particles on the bottle wall do not affect the count, as long as the wall is not in the sensitive zone. However, optical discontinuities should be avoided.

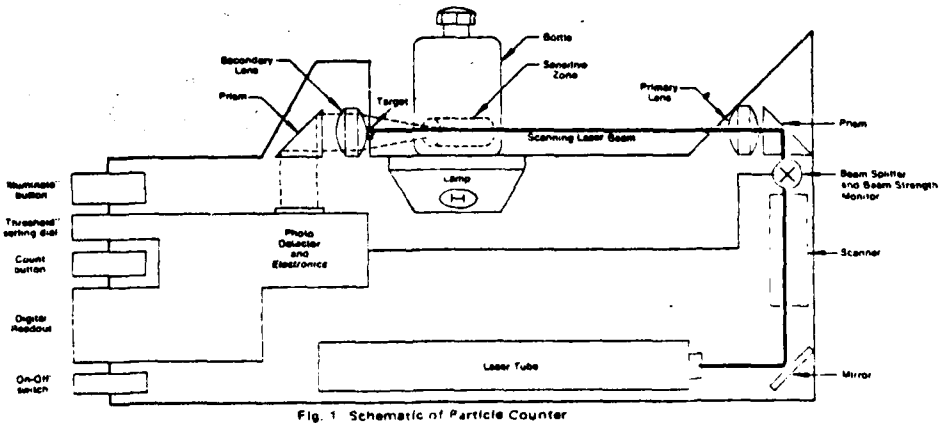


Fig. 1 Schematic of Particle Counter

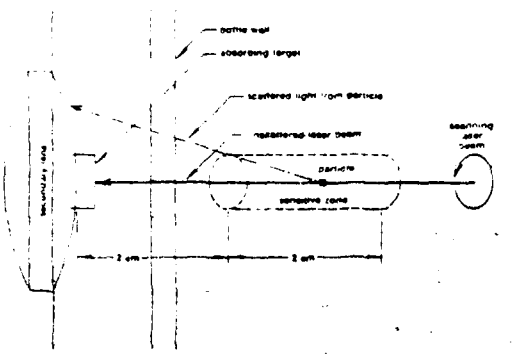


Fig. 2: Laser Beam Optics.

Once the count button is pushed, the revolving laser beam scans a total volume of 10 cc in 15 seconds, and the digital readout displays the average number of particles with sizes above the threshold limit in one cc of liquid.

By taking sequential measurements, qualitative size distribution data can be developed, or the threshold selector can be locked to provide statistical quality control data at one setting.

MAINTENANCE

The Prototron Particle Counter is fully covered by a one year warranty and the laser life is rated at 10,000 hrs. The warranty includes replacement of the illumination lamp and the laser tube. Other than such normal replacement, the unit is virtually maintenance free.

OPERATION

The operation of the Prototron Particle Counter consists of three steps: (1) Gently agitate the sample of bottled liquid to produce a uniform suspension, (2) Place bottle in the "V" notch and rotate to a point where the laser beam enters and leaves *unobstructed*. (3) *Press the "Count"* button. Within 15 seconds, the total particle count per cc is displayed on the digital readout.

In addition, by pressing the "Illuminate" button, a light table may be used to visually detect particles larger than 40 microns. The light table goes off when the "Count" button is pressed.

SAFETY

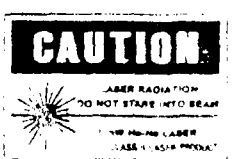
The laser used in the Prototron Particle [illegible] at one milliwatt and averages [illegible] primary lens. Virtually all laser [illegible] sorbed by the target. The Electronic Industries Association has recommended that the [illegible] and OSHA accept lasers with energies of 5 milliwatts or less, for relatively unrestricted usage. Therefore, the Prototron Particle Counter is well within the safety regulations.

SPECIFICATIONS

Size	18" (45.72 cm) high, 9" (22.86 cm) wide, 24" (60.96 cm) deep
Weight	31 pounds (14.06 kg)
Power	115 volts, 60 Hz (can be modified to 230 volts, 50 Hz on special order)
Display	3 digits
Outputs	Connections provided for external alarm, printer, oscilloscope or pulse height analyzer
Bottle Size	20 to 200 mm inside diameter
Bottle Material	Transparent, scratch free glass or plastic
Read-Out Volume	1 cubic centimeter
Detectable Particle Size	Continuously adjustable from 1 to 100 μm
Warranty	One year on parts

ORDERING INFORMATION

The Prototron Particle Counter may be ordered direct from Spectrex Corporation. It may also be leased with an option to buy plan. To arrange a lease call collect (415) 365-6567. Quantity discounts are available. For more information, write or call Spectrex Corporation.

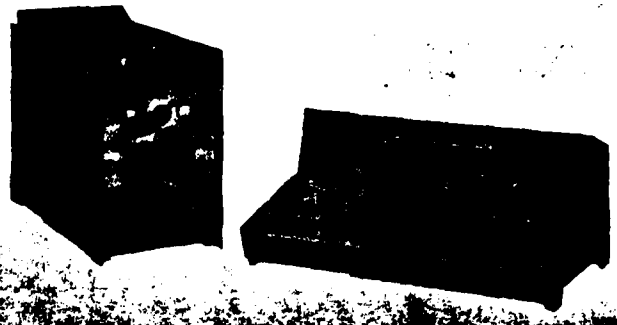


SPECTREX CORPORATION
3594 HAVEN AVENUE, REDWOOD CITY, CALIFORNIA 94063

NAEC-92-146

SPECTREX
CORPORATION
3594 HAVEN AVENUE, REDWOOD CITY, CALIFORNIA 94063, (415) 365-6567

PRICE QUOTATION



LASER PARTICLE COUNTER and ACCESSORIES

ITEM NO.	QUAN-TITY	DESCRIPTION	CAT #	PRICE
1	1	ILI 1000 Particle Counter (110V) including: (1) carrying case; (2) 3 bottles; calibrated check suspensions (3) neutral density filter.	67000	$8200.00
2	1	Particle Profile Attachment Model 3. (Microprocessor with "mass distribution" and "settling scan" modes.).	67008	$5500.00
3	1	Opacity Meter.	67012	$ 350.00

F.O.B. REDWOOD CITY, CALIFORNIA

THIS QUOTATION IS VALID FOR 60 DAYS

8/1/79 jmh/amk

PROTOTRON
PARTICAL
COUNTER

3694 HAVEN AVENUE
REDWOOD CITY CALIF
(415) 365-6

APPLICATION NOTES . . . . . .

CLASSIFICATION OF HYDRAULIC FLUIDS

Several standard classification systems have been established for hydraulic fluids based upon their particulate content. A typical one recommended by SAE is NAS 1638 which specifies maximum concentration limits for particles ranging in diameter from 5 micrometers to over 100 micrometers. The Prototron ILI-1000 provides a quick method of establishing the class number of an unknown fluid.

First a 200 ml sample of the unknown is placed in a 250 ml beaker and stirred to establish a uniform particulate distribution. The sample is allowed to remain quiet for approximately 20 seconds so that air bubbles can escape. It is then placed upon the ILI-1000 and five readings are taken, resetting the instrument threshold level between each reading. These readings would for example give the number of particles per milliliter greater than 100 micrometers, the number greater than 50, the number greater than 25, the number greater than 15, and the number greater than 5. By subtracting the second reading from the first, the number of particles in the range between 50 and 100 can be determined. In a similar fashion each of the other specified size ranges can be determined. These values are then compared with the maximum limits keeping in mind that many limits are given on the basis of 100 milliliters.

For very clean fluids an averaged series of readings at each level can be used to increase the statistical significance of the determinations. This is possible because the test is non-destructive. This represents a significant advantage over other available automatic particle counting systems.

If the fluid is very dirty it may contain more than 1000 particles greater than 1 micrometer per milliliter. This should be checked and if it is the case the sample should be diluted with a well filtered clean solvent and the measured particle concentration corrected for this dilution ratio. Keeping the count less than 1000 will prevent excessive co-incidence counting from destroying the accuracy of the determination.

An example of a test of MIL-H-5606 hydraulic fluid which has been added 0.5 mg/liter of AC FINE test dust) follows:

Size Threshold	Reading	Differential part/ml	Class 8 Max Limits part/ml
5	227		
		227-35 = 192	640
15	35		
		35-11.5 = 23.5	114
25	11.5*		
		11.5-2.4 = 9.1	20
50	2.4*		
		2.4-0.5 = 1.9	3.6
100	0.5*		
		0.5-0.0 = 0.5	0.6

* These readings are average of 10 counts to increase the statistical significance.

Because the differential values are all less than the Class 8 Max Limits we can conclude that this test fluid corresponds to Class 8 of NAS 1638.

SPECTREX
COMPANY
3594 HAVEN AVENUE, REDWOOD CITY, CALIFORNIA 94063, (415) 365-6567

COMPARISON OF THE SPECTREX "PROTOTRON" TO OTHER PARTICLE COUNTERS

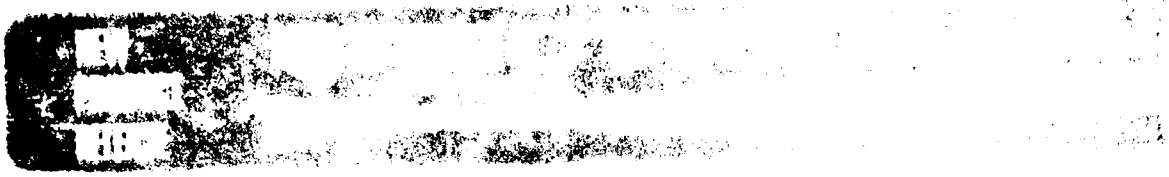
The Coulter Counter is designed to count blood cells and does an excellent job for this specialized application. It works on the principle that blood cells do not conduct electricity but blood plasma does. A diluted sample flows through an insulating orifice, and the electrical resistance of the liquid column within the orifice is measured. Passage of a blood cell will change the resistance, and these resistance changes can be counted. The orifice must be very small and is therefore easily plugged by large particles. The dynamic range is for this very reason severely limited. The flow rate is also very small.

The Hiac and the Royco Particle Counters use optical light scattering and a flow cell to count particulates. The optical light scattering overcomes the dynamic range limitation of the Coulter method, and liquids other than electrolytes can be examined. The flow cell still limits the flow rate but not as severely as does the Coulter orifice. The largest disadvantage of these optical particle counters is that the flow cells require windows and these windows become dirty with use. Dirt on the windows effects the accuracy of the calibration and usually forces the user to frequently clean the cell and re-calibrate the instrument. The rapidly moving liquid in the cell generates pressure waves which usually limit the smallest detectable particle to 2 microns.

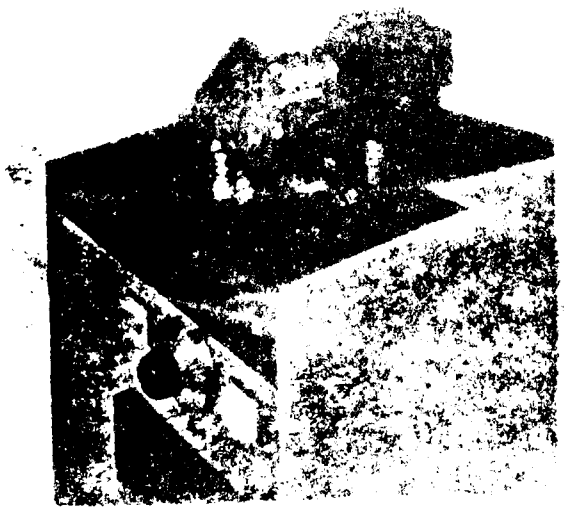
The Prototron also uses optical light scattering but its method is unique in that the liquid is moving very slowly and therefore contains no pressure waves. The laser beam is moving rapidly to produce the necessary scanning. This accounts for the greater sensitivity of the ILI-1000 and permits measurement of particles as small as one micron. The time required for a single determination of these small particles is substantially faster than with any other counting method. The other unique feature of this instrument is the optical system which keeps the sample container walls out-of-focus and, therefore, counts only the particles suspended in the liquid. This feature permits the measurement of particulates in sealed containers.

When flow cells are used, a flow measuring system is also required, and the count accuracy is limited by accuracy of this flow measuring system. The ILI-1000 electronically times the scan period and, therefore, avoids inaccuracies in flow measurement associated with all other automatic particle counters.

9/24/74 amk

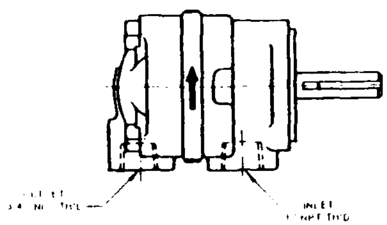


OPACITY

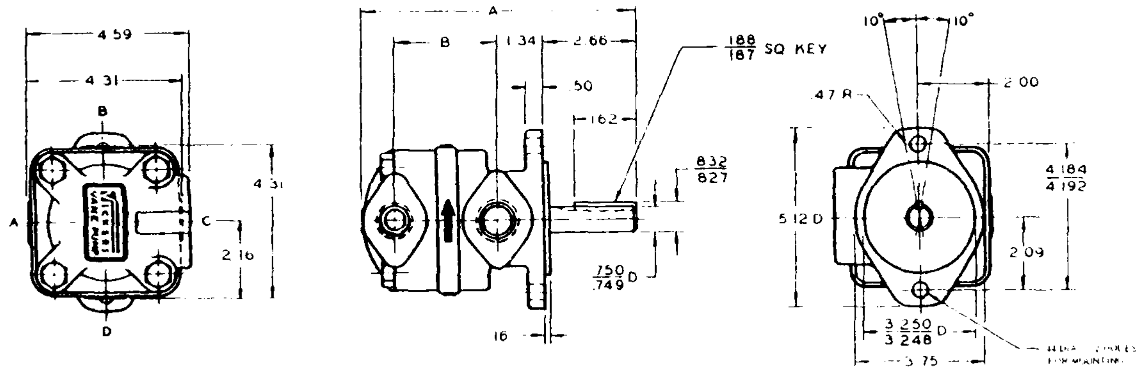


VICKERS. VANE TYPE CONSTANT DELIVERY SINGLE PUMPS
SERIES V200-S214
FOR USE WITH OIL OR FIRE RESISTANT FLUIDS

OUTLET ASSEMBLED IN LINE WITH INLET IS DESIGNATED BY C IN MODEL NUMBER
OPTIONAL LOCATIONS OF OUTLET
A OPPOSITE INLET
B 90° COUNTERCLOCKWISE FROM INLET
C 90° CLOCKWISE FROM INLET



CAUTION AIR BLEED
AT TIME OF FIRST STARTING IF THE PUMP DOES NOT IMMEDIATELY PRIME AIR SHOULD BE BLED FROM PUMP DELIVERY LINE. THIS MAY BE ACCOMPLISHED BY LOOSENING A CONNECTION IN THE DELIVERY LINE CLOSE TO THE PUMP UNTIL OIL FLOWS INDICATING PUMP HAS PRIMED.



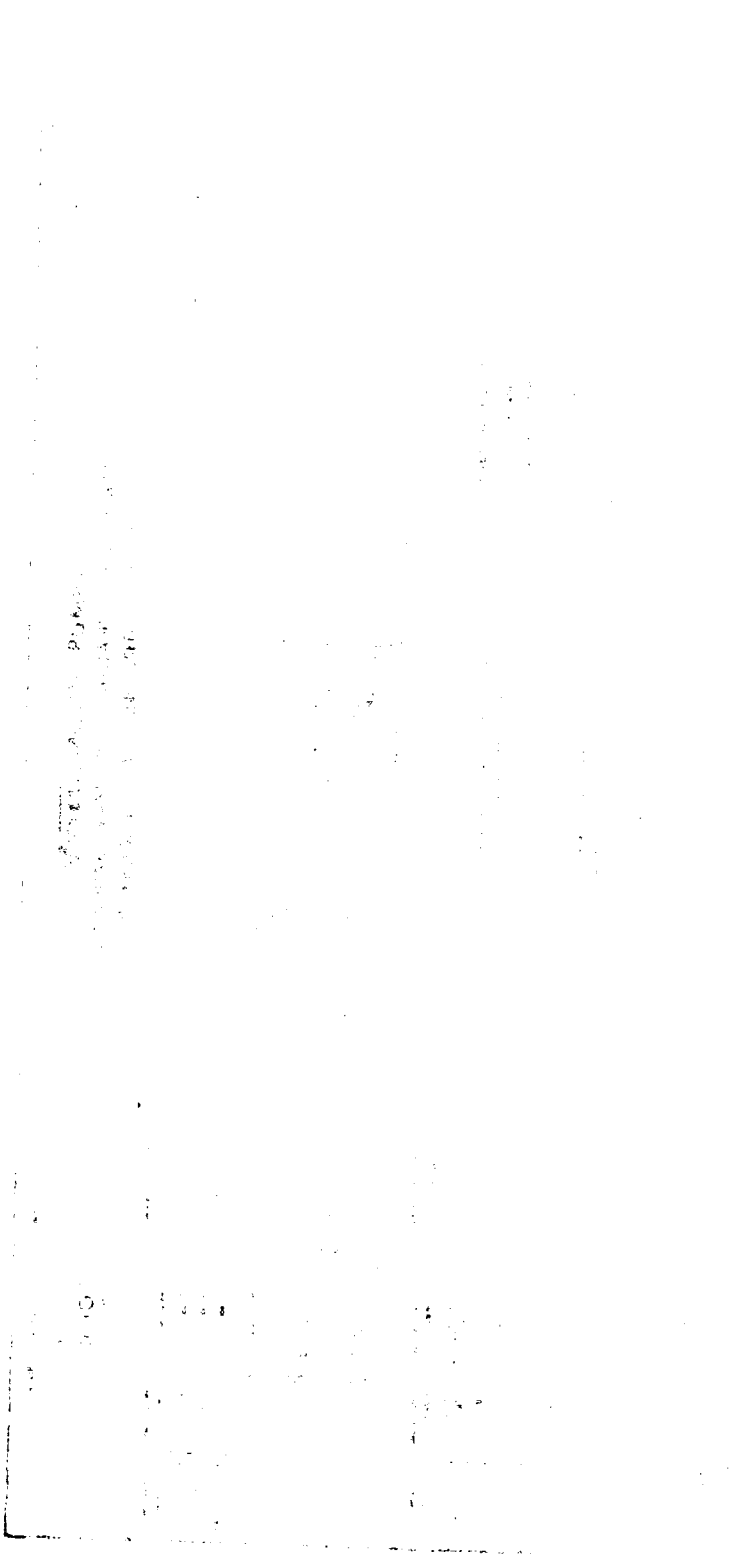
MODEL V210-*-1C-12-S214
(FLANGE MOUNTING)

MODEL NUMBERS — USE AS LISTED FOR PETROLEUM & WATER CONTAINING FLUIDS. FOR SYNTHETIC FLUIDS ADD F3 PREFIX. SEE SYNTHETIC FLUIDS PARAGRAPH FOR EXPLANATION			● OPERATING CHARACTERISTICS AT 1200 RPM DATA BASED ON PERFORMANCE AT OIL TEMPERATURE OF 120° F VISCOSITY 150 SSU AT 100° F										MAXIMUM SPEED (RPM) WHEN USED WITH FLUID TYPES INDICATED			DIMENSIONS		MAX. PRESSURE PSI WHEN USED WITH FLUID TYPES INDICATED	
			100 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI								
FACE MOUNTING	FOOT MOUNTING	FLANGE MOUNTING	GPM	HP	GPM	HP	GPM	HP	GPM	HP	GPM	HP	PETROLEUM OIL	SYNTHETIC	WATER CONTAINING	A	B	PETROLEUM AND SYNTHETIC	WATER CONTAINING
[illegible] 2 1C 12 S214	V214 2 1C 12 S214	V210 2 1C 12 S214	2 3	0 4	2 1	1 2	1 9	2 1	1 8	3 4	1 6	4 0	1800	1800	1800				
[illegible] 5 1C 12 S214	V214 5 1C 12 S214	V210 5 1C 12 S214	5 4	0 7	5 0	2 2	4 7	4 1	4 5	6 1	4 3	8 7	1800	1800	1800	7 62	2 69		
[illegible] 6 1C 12 S214	V214 6 1C 12 S214	V210 6 1C 12 S214	6 6	0 6	6 0	2 6	5 8	4 9	5 4	7 2	5 2	9 4	1800	1800	1800			2000	1500
[illegible] 8W 1C 12 S214	V214 8W 1C 12 S214	V210 8W 1C 12 S214	8 0	0 9	7 6	3 0	7 2	5 7	6 9	8 4	6 6	11 0	1800	1200	1800	7 86	2 94		
[illegible] 9W 1C 12 S214	V214 9W 1C 12 S214	V210 9W 1C 12 S214	9 0	0 9	8 4	1 6	8 2	7 0	8 1	10 7	7 7	13 5	1800	1200	1800				
[illegible] 11W 1C 12 S214	V214 11W 1C 12 S214	V210 11W 1C 12 S214	10 9	1 2	10 2	4 2	9 7	8 0	9 3	11 8	8 9	16 0	1800	1200	1800	8 06	3 12		

● WHEN DISCHARGE PRESSURE IS BELOW 100 PSI PUMP DELIVERY IS REDUCED APPROXIMATELY 10 TO 15 PER CENT

REVISED 7 63 R.W.S.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
DETROIT, MICHIGAN, U.S.A.
INSTALLATION DRAWING
I-236693



SOLID-STATE POWER CONVERSION EQUIPMENT

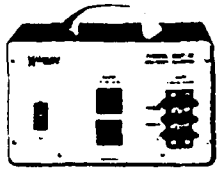
STANDARD CUSTOM INDUSTRIAL MILITARY

DC-TO-AC INVERTERS

UPS/STANDBY POWER

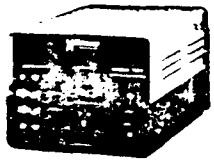
MODEL 1057 300-WATT INVERTER

Economically priced and ideally suited for waveshape sensitive electronic equipment such as oscilloscopes, chart recorders and video tape recorders, the frequency stable 300 VA Model 1057 inverter is an inexpensive alternative to sine wave power. The switching-mode wave-shaping technique yields a three-level step wave-shape which has approximately the same peak-to-rms voltage ratio as a true sine wave. The Model 1057 inverters are protected against overloads, short circuits and reversed polarity of dc input line. Versions for input voltages of 12 Vdc, 24 Vdc, 32 Vdc and 36 Vdc are standard. Outputs of 115 Vac/60 Hz or 230 Vac/50 Hz are also standard. All models are approximately 80% efficient from one-half to full load and have a frequency stability of ± 0.25%. The Model 1057 is packaged for portable or stationary use, with a convenient carrying handle. All versions are 8¾" high x 11" wide x 8½" deep and weigh 25 pounds. Units are shipped from stock. Single piece price for all versions is $374.00 each. Resale, OEM, and quantity discounts are available. Request bulletin 9091C.



MODEL 1057

MODEL 1172 HEAVY-DUTY INVERTER



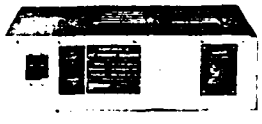
MODEL 1172

The Model 1172 is an inexpensive, rugged, 500-watt square-wave inverter designed to power heavy duty loads. This inverter will provide a 2 to-1 surge, approximately 1000 watts, for high-inrush loads such as small power tools, refrigerator compressors and incandescent lights. The Model 1172 is a modular inverter and two units may be easily paralleled in the field for added continuous and surge power. Versions for input voltages of 12 Vdc, 24 Vdc and 32 Vdc are standard. Output voltages of 115 Vac or 230 Vac and 50 Hz or 60 Hz are also standard. All versions are more than 80% efficient for most of their output load range. The frequency stability is ± 2 Hz and the output voltage is proportional to the input voltage. All Model 1172 inverters are 7" high x 8½" wide x 11" deep and weigh 32 pounds. The single piece price of all versions is $335.00 each. Resale, OEM, and quantity discounts are available. Units are normally shipped from stock. Request bulletin 1011A.

Wilmore Electronics manufactures other inverters in the 15-watt to 500-watt power range. Other square-wave-output inverters are available, and for those loads that are extreme- wave-shape and frequency sensitive, regulated stepped-wave or sine-wave inverters are also available. Please contact our sales department for information.

MODEL 1252 AUTOMATIC STANDBY AC POWER SUPPLY

Serious problems may result when commercial ac power is unexpectedly interrupted to sensitive loads, such as point of sale terminals, communication systems or monitoring equipment. Such interruptions are becoming more commonplace and many people are exploring point of use uninterruptible power supplies like the Wilmore Model 1252 to keep their systems operating. When commercial ac power fails, this standby ac power source continues to supply needed power to your load by switching to inverter operation. Upon restoration of ac power, the Model 1252 automatically returns to normal line operation, and the internal battery charger recharges the batteries. Two basic versions are available, one providing a three-level-stepped wave approximation to a sine-wave output and 250 watts of power, and the other supplying 500 watts of square-wave power. Standard battery input voltages are 12 Vdc and 24 Vdc. All units are 5¾" high x 17" wide x 14" deep and weigh 45 pounds. They can be installed in a standard 19" rack or they may stand alone. The Model 1252 system consists of inverter, battery charger and switchover/protection circuitry. The battery is not included. The user has the flexibility to size and specify a battery to fit his particular system and desired back-up time. Single piece price is $575.00 each. Resale, OEM, and quantity discounts are available. The Model 1252 is normally shipped from stock. Request bulletin 6021.



MODEL 1252

NEW INVERTER AND UPS PRODUCTS

- 50 VA to 1 KVA
- High Surge Capability
- Frequency Stable
- Rugged but Lightweight
- Highly Efficient (80% Typical) and Low No Load Power Consumption

With models ranging in power rating from 50 VA to 1 KVA, the Series 1400 inverters considerably broaden Wilmore's dc-to-ac product line. To be introduced in mid-1980, these conservatively designed inverters represent rugged, reliable, cost-effective solutions to a wide variety of needs for frequency-stable ac power. Their improved output waveshape, surge-handling capability, and ability to handle a wide range of load power factors ensures compatibility with most loads, even those normally considered to be "troublesome" for solid-state inverters.

Concurrently with the introduction of the Series 1400 inverters, Wilmore is introducing the Series 1401 Uninterruptible Power Supplies. As with the Series 1400 inverters, on which this UPS line is based, models within the Series 1401 range in power rating from 50 VA to 1 KVA. Normally sold without a battery, Series 1401 models feature a self-contained battery charger, frequency stable inverter and line-to-inverter [illegible] circuitry.

Wilmore ELECTRONICS CO., INC.
P.O. Box 1329, Hillsborough, N.C. 27278 U.S.A.
Telephone (919) 732-9351

APPENDIX B

VIBRATION SIGNATURE ANALYSIS OF AHT-64 HYDRAULIC TEST STAND

NOTE: The 19 figures presented in this appendix were extracted from a total of 78 charts. These are discussed in the analysis.

VISPCO *VIBRATION SPECIALTY CORPORATION*

100 Geiger Road Philadelphia Pa 19115
(215) 698-0800

March 30, 1979

Mr. Edwin Roberts
Sanders & Thomas
[illegible] Box 5[illegible]
[illegible]

[illegible]

[illegible] purchase order C-26024, our engineer [illegible] and Willow Grove Naval Air Stations [illegible] 1979. Our purpose was to perform a [illegible] of two AHT-64 hydraulic test stands [illegible] amplitudes and frequencies.

[illegible] at seven locations on the test [illegible] diagram. Signatures were recorded [illegible] and axial directions under idle [illegible] RPM), loaded (3000 psig), unloaded [illegible] signature (see Figure A) shows [illegible] acceleration versus frequency in hertz. [illegible] logarithmic with full scale equal [illegible]. The frequency (horizontal scale) is [illegible] with 4 Hz resolution. Described in the [illegible] test position, total overall vibration [illegible] and test stand operating

[illegible]

[illegible] amplitude response varied by a factor of two or more [illegible] test stands due to structural integrity differences, [illegible] energy differences. Vibration frequency response was constant at both test stands - that is, 360 hertz was the major [illegible] and response frequency.

DISCUSSION

Basically all input energy was measured at positions 6 and 7. Test position 6 was the hydraulic pump, where loaded (3000 psig) and unloaded (zero gauge) pressure variations were tested. Measured and recorded were the change in vibration energy levels produced by the two conditions.

Stand #143 showed considerable increase in vibration (almost double) with load (see Figures 20 and 41). Stand #117 showed very

little increase (about 10 percent), as seen in figures 60 and 77. The major vibration frequency was 360 hertz, or nine times the operating speed (2400 RPM = 40 hz). It was determined that the pump had nine pistons working axially, which explains the high ninth harmonic response in all test positions, predominantly in the axial direction.

Test position seven was the diesel engine on both stands, rotating at 2400 RPM, with or without pressure load on the pump. The engine vibration levels recorded on each stand were very similar, and there were no appreciable changes with pump loading (Figures 22, 43, 62 and 78). The major frequency source from the diesel was the 40 hz signal and the associated harmonics.

Structural vibration response was measured and its freqency spectrum signature recorded at five different locations on the AHT-64 structure. Remember, the major frequency on all signatures on both test stands was 360 hertz.

The highest amplitude response (2.2g) on stand No. 143, was at position 5 (Figure 36) which is the underside of the base structure of the stand. A level almost equal to this (2g) was recorded in the axial direction at positions 1 and 3 (figures 26 and 32). Positions 2 and 4 showed levels around 1.5g (Figures 29 and 35).

In comparison, test stand No. 117 had the highest response (7g) at position 4 axial (Figure 73). The next highest response on stand No. 117 was 3 to 4 g's (still higher than No. 143) at positions 2 and 3 (Figures 67 and 68). Positions 1 and 5 had levels around 1 to 2 g's.

The only explanation for this drastic difference in response between these two test stands would be the way the control panel is connected to the rib structure at those points. In other words, stand No. 143 is stiffened by the ribs being rigidly connected together by the control panel and stand No. 117 is less rigid by being loose or possibly not connected at all, thereby allowing this center point to vibrate excessively.

CONCLUSION

The excitation energy on each test stand was similar, producing a similar frequency response. However, the amplitude response was different by a factor of two or more. Therefore, the instrument package which is to be mounted on the AHT-64 structure must be able to withstand vibration frequencies around 360 hertz. However, the amount of vibration energy it must withstand is still in question.

If we assume that test stand No. 143 had "good" structural integrity and needs no further reinforcements, etc., and we assume that test stand No. 117 could be fixed and/or reinforced enough to respond similar to No. 143, then the amount of vibration energy which

NAFC-92-146

Mr. Edwin Roberts
Sanders & Thomas

March 30, 1979

Page Three

must be withstood by the instrumentation would be 2 g's if mounted on the front of the stand below the control panel (positions 1,2 and 3).

RECOMMENDATION

Assumptions were made in the last paragraph which we recommend be eliminated through further testing, inspections, and modifications. The future tests would not have to be as detailed in terms of frequency response, only amplitude response. Amplitude can be measured and recorded more easily than the previous tests using a transducer and an overall vibration meter capable of displaying at least two of the three engineering parameters - acceleration, velocity, and displacement.

I would estimate four to six test stands could be monitored in one day, obtaining the orthogonal amplitude responses at the same seven locations on the stand operating in the pressure loaded condition. It would be advisable to inspect the test stands closely for loose bolts, cracked welds or structural members. This can be done with the same vibration meter with a strobe light attachment. If differences were found through this inspection, I would suggest corrective measures be performed if possible. In this way we would be assured of similar structural integrity between test stands.

Our charges for the engineering testing and analysis would be $500 per day of on-site services. There would be no additional charge for analysis completed in our engineering center. Travel and per diem expenses incurred during the test program are also included in the above price.

We thank you for the opportunity to provide our service. If you have any questions, please do not hesitate to contact us.

Very truly yours,

Bill Keeley

WILLIAM D. KEELEY
Field Service Manager

WDK/cm

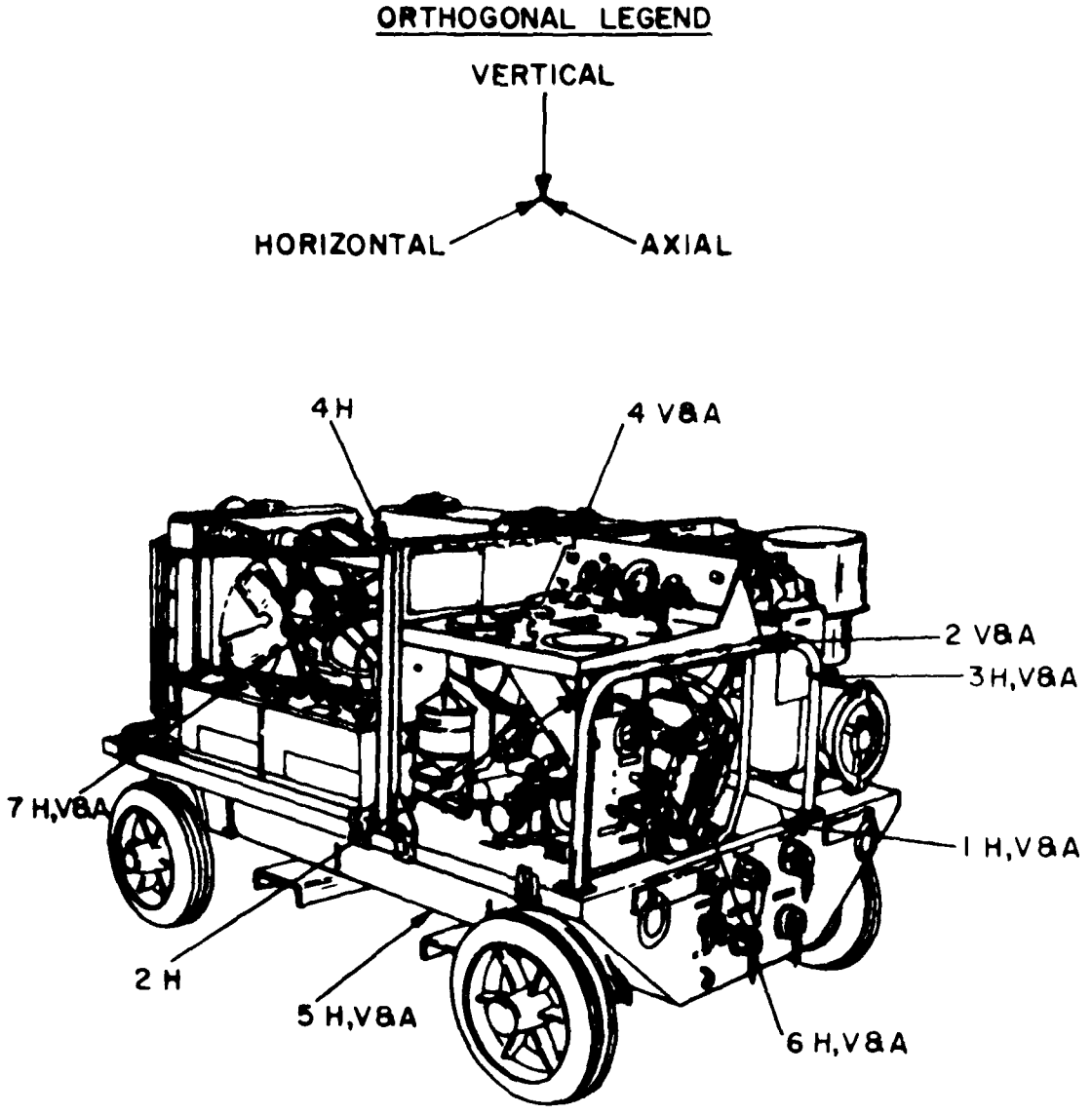
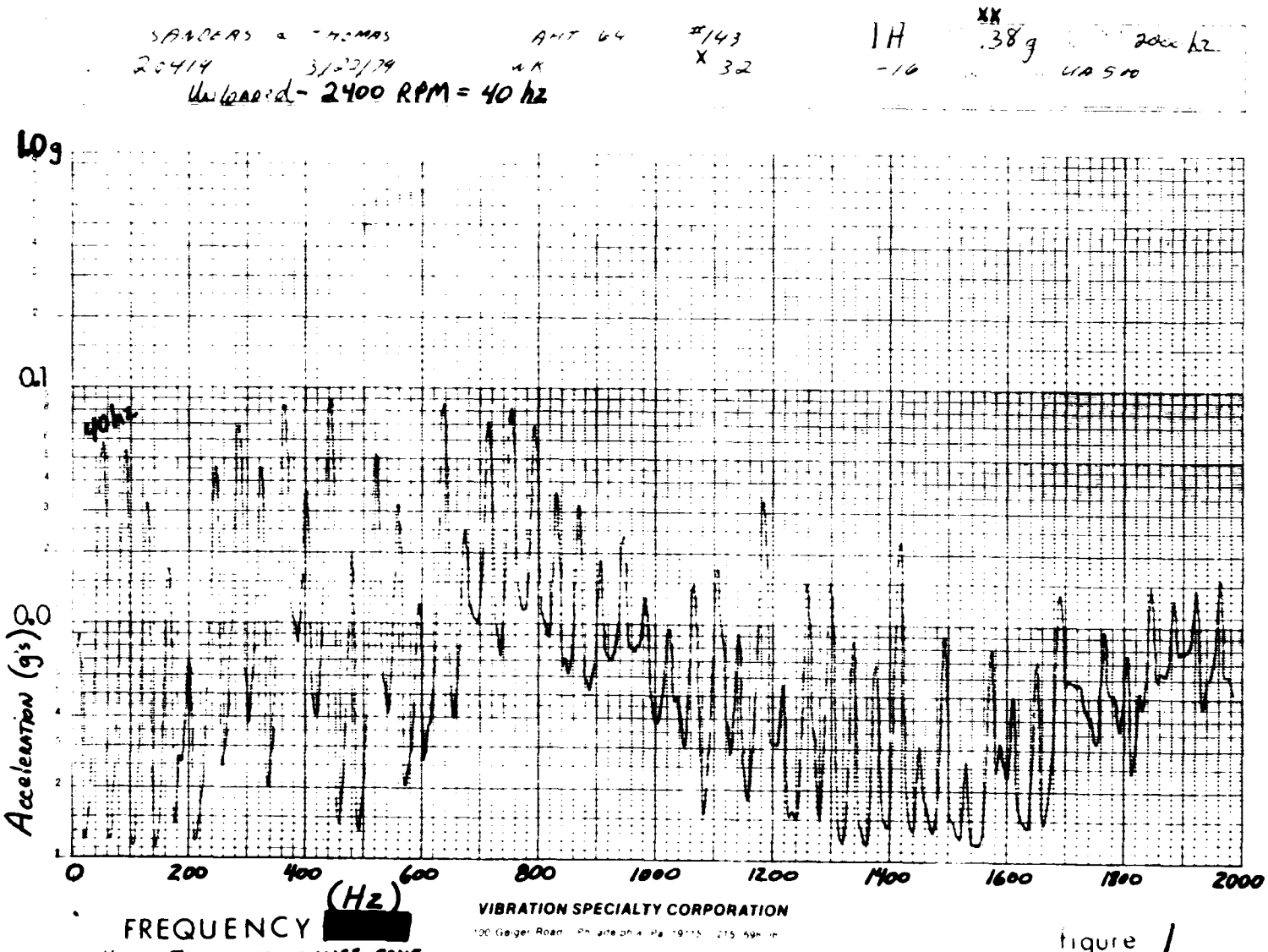


Figure A - Vibration Signature Positions



NOTE: FREQUENCY RANGE SAME FOR ALL SUBSEQUENT FIGURES IN APPENDIX B.

figure 1

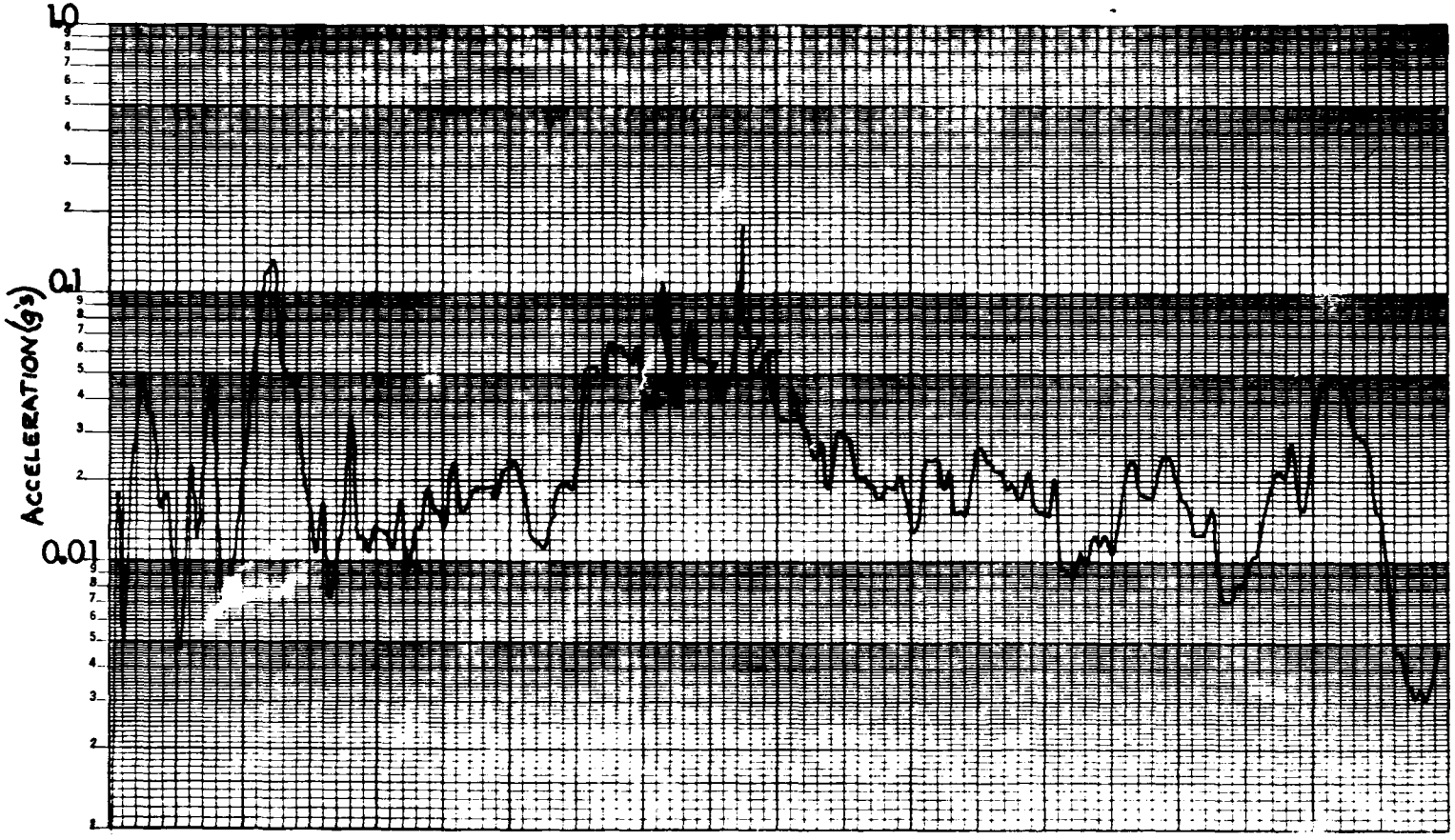
X No. of samples looked at/analyzed over 0-2000 Hz Range

XX Summation of G's over 32 sample points (in 0-2000 Hz Range)

CUSTOMER SANDERS + THOMAS EQUIPMENT AHT-64 #143 POSITION IV OVERALL LEVEL — FREQUENCY RANGE 2000 hz

JOB NO. 20419 DATE 3/22/79 ANALYST WK AVERAGE 32 dB -16 INPUT FROM UB50

TEST CONDITIONS Transient - Idle to Full Speed - Unloaded



FREQUENCY

VIBRATION SPECIALTY CORPORATION
100 Geiger Road Philadelphia Pa 19115 (215) 698-0800

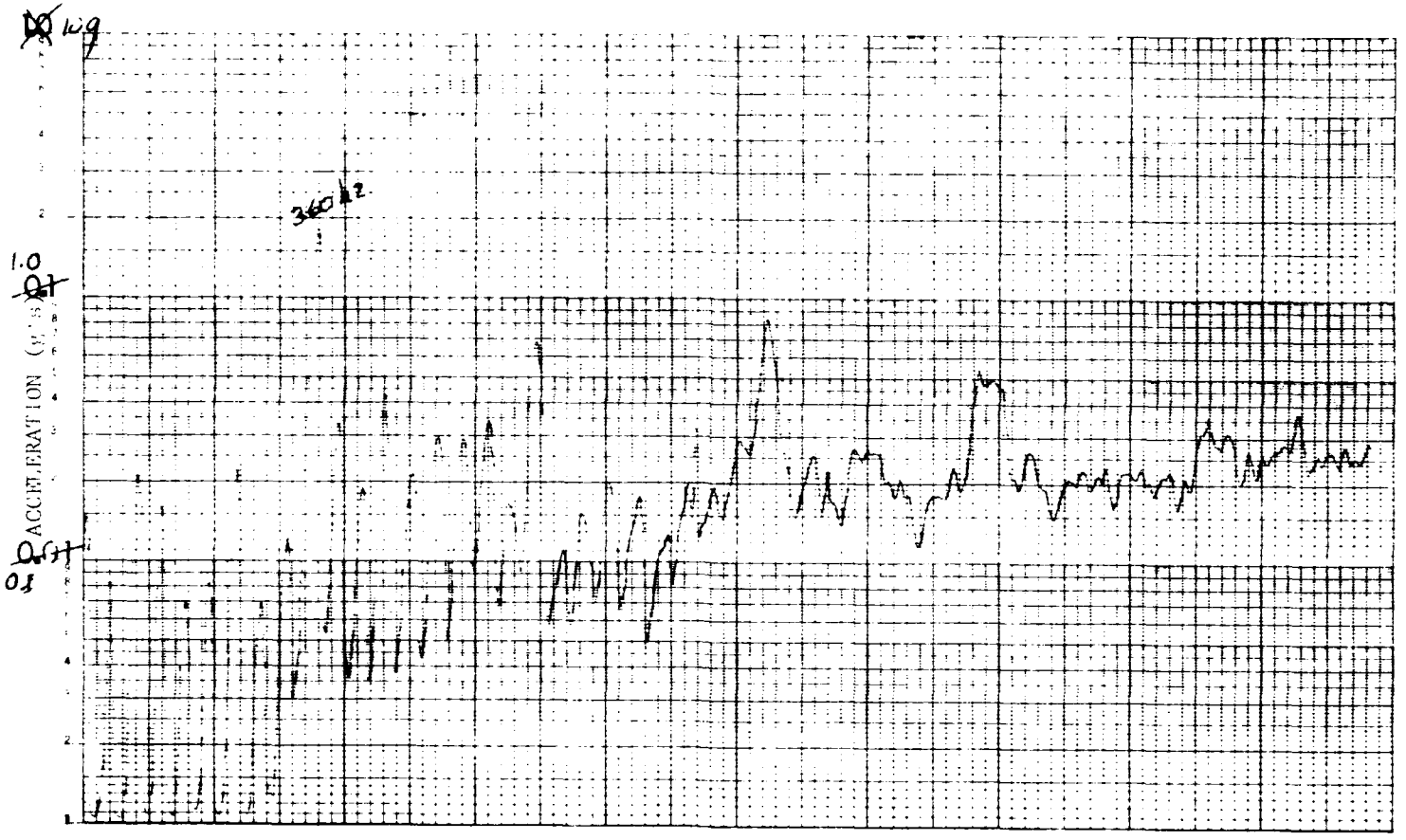
figure 3

87 (B-7)

Sanders & Thomas AHT-64 #143 CA — 2000 hz

26419 3/22/74 WK 32 -16 UA500

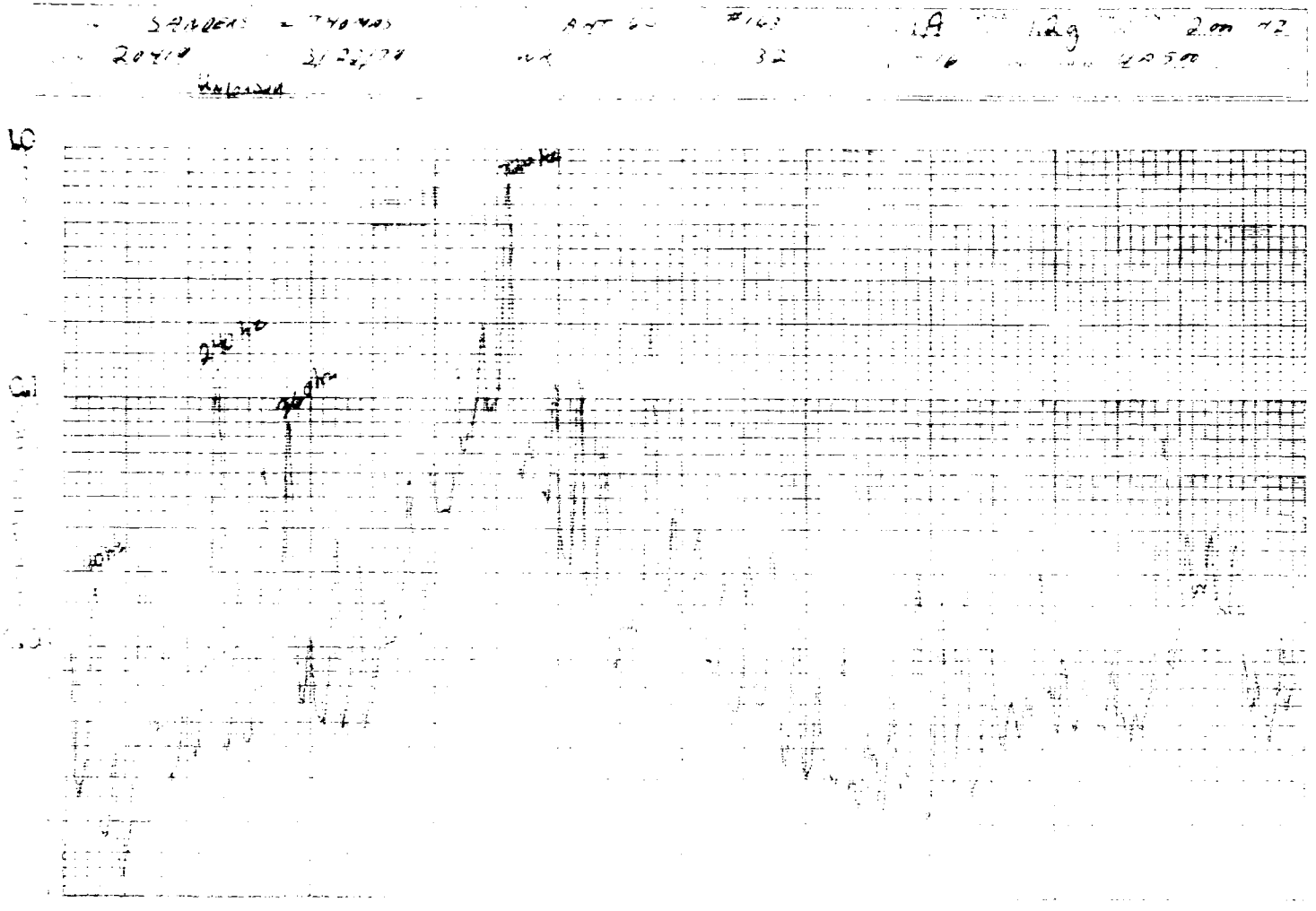
TRANSIENT From Loaded to Unloaded Pressure



FREQUENCY

VIBRATION SPECIALTY CORPORATION

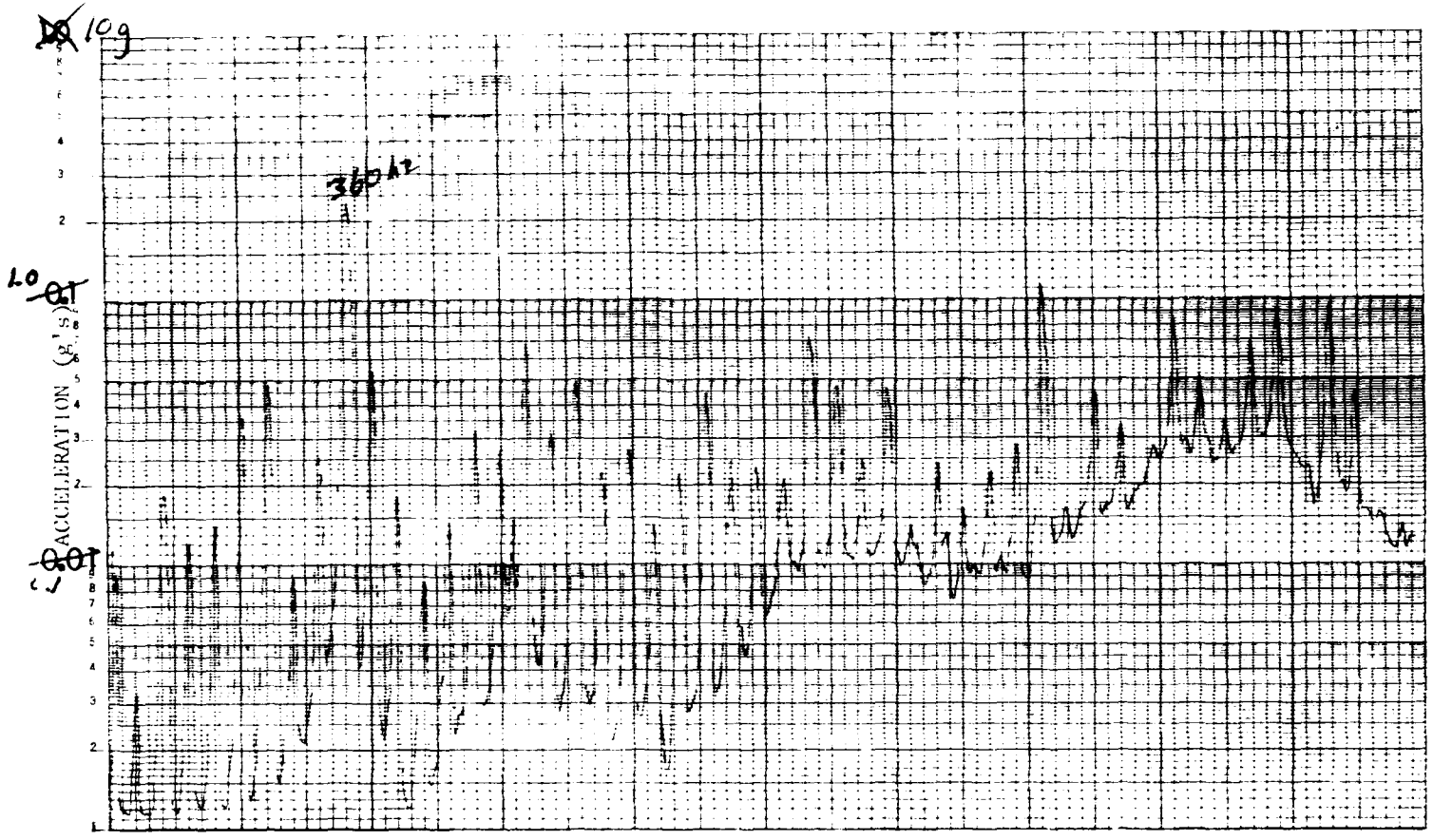
figure 4



FREQUENCY

Figure 5

SANCORS & THOMAS AMT-64 #143 6A 6.8g 2000 hz
2-419 3/22/79 WK 32 -16 48500
Unloaded



VIBRATION SPECIALTY CORPORATION

Figure 20

90 (B-10)

NAEC-92-146

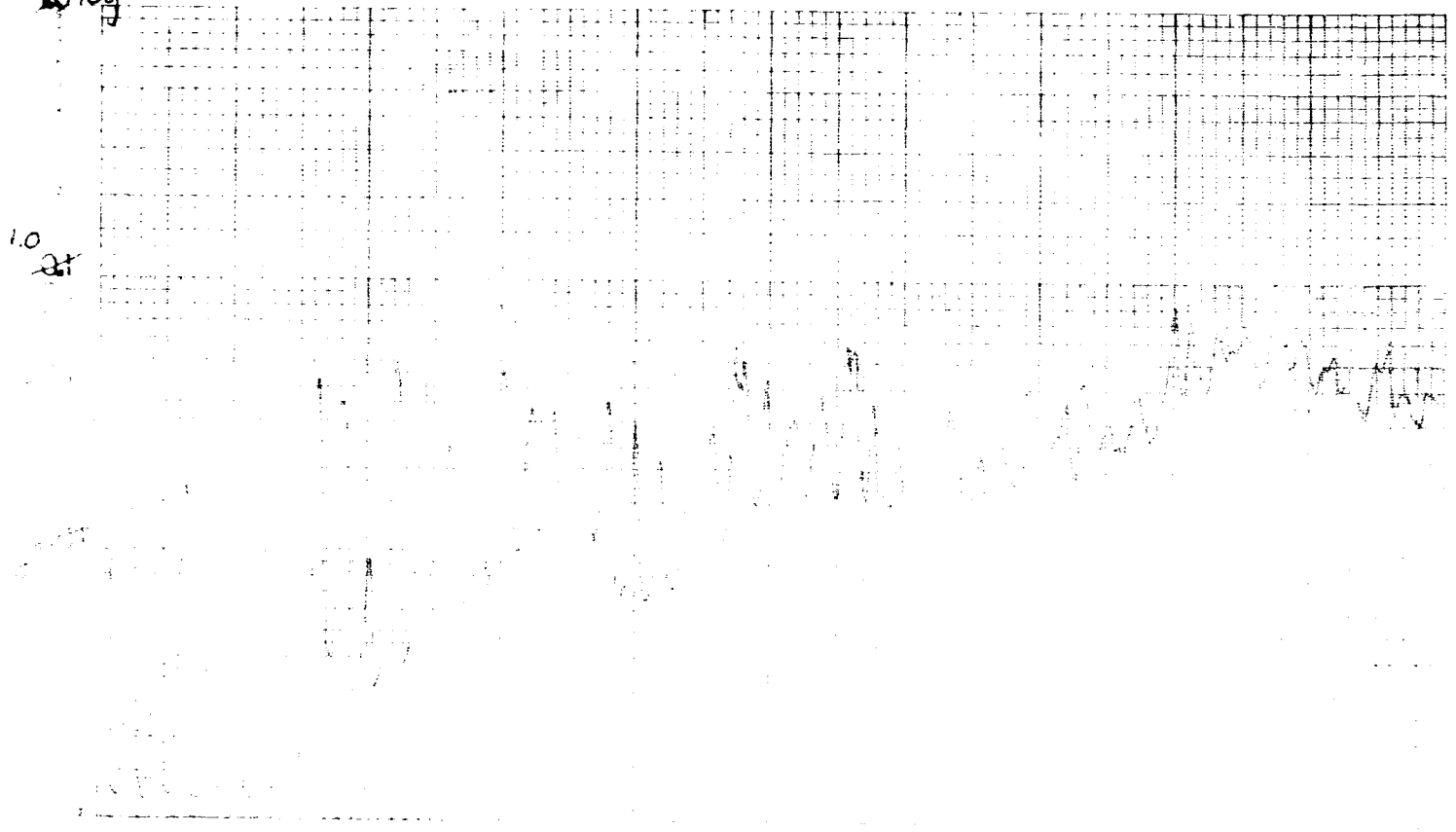
SANDERS & THOMAS A4T-64 #143 7V 9.5g 2000 hz

2041? 3/27/79 uK 32 -16 4450

Unloaded

10g

1.0



FREQUENCY

VIBRATION SPECIALTY CORPORATION

Figure 2?

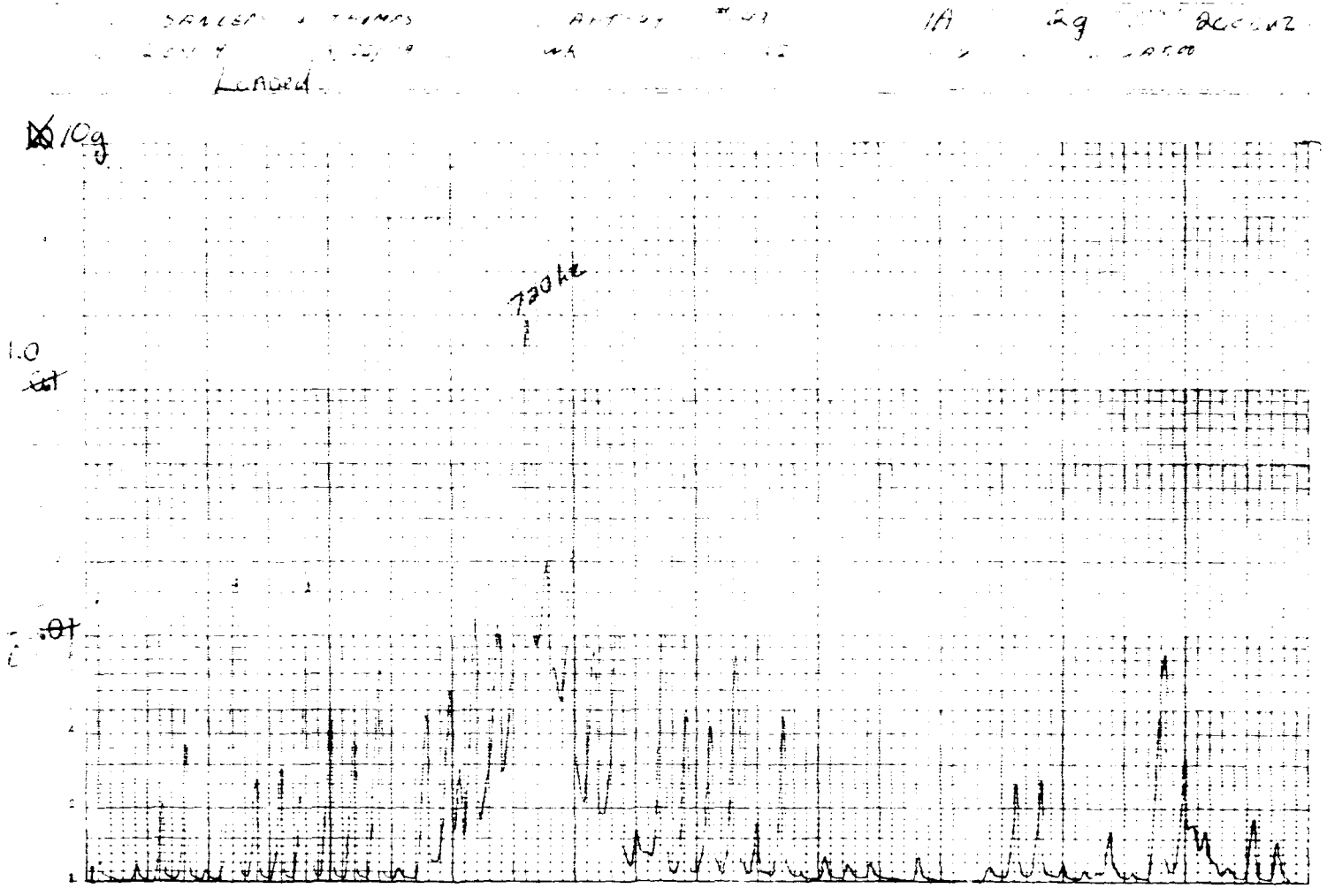
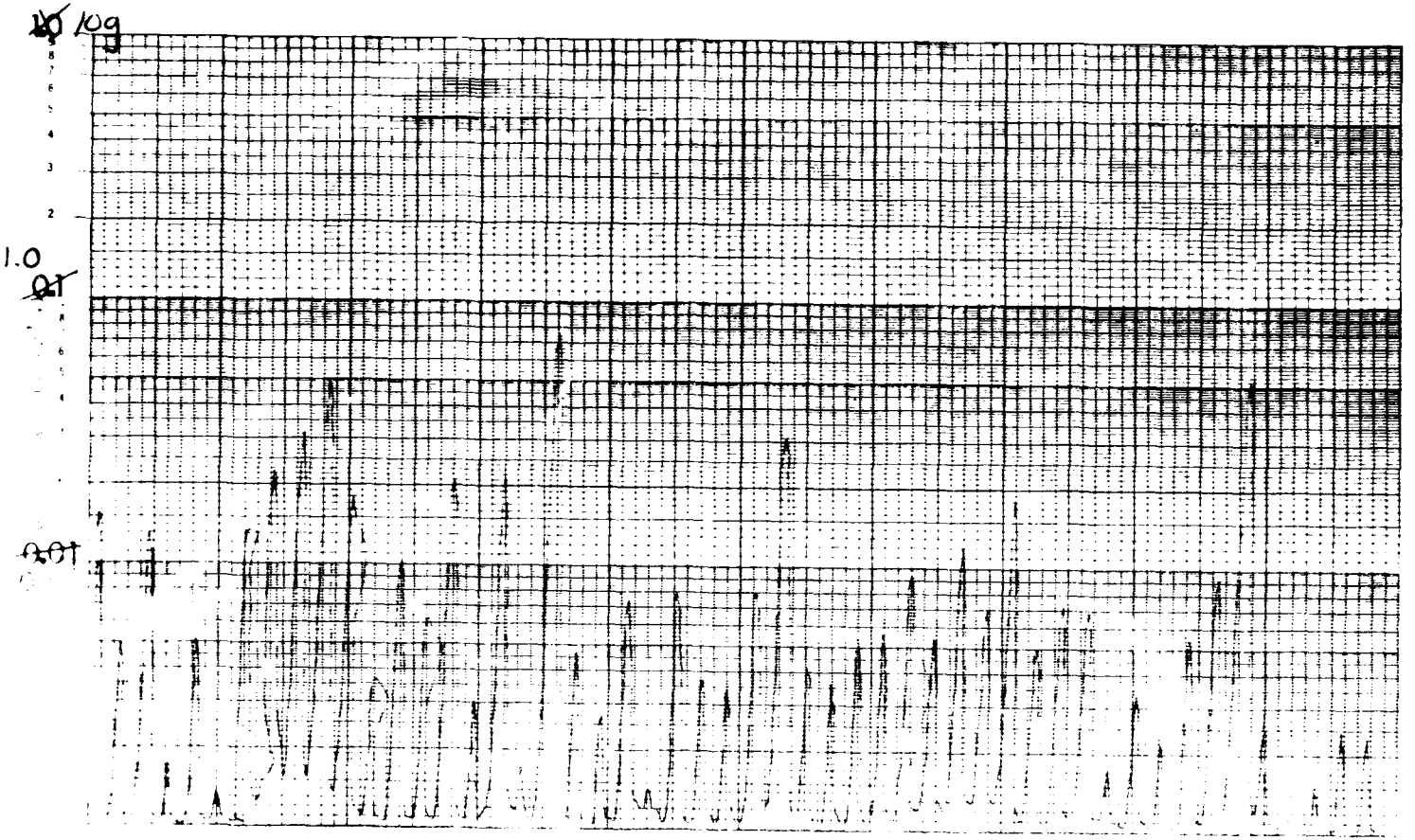

10g
1.0
.01
720Hz
FREQUENCY
VIBRATION SPECIALTY CORPORATION

figure 26

SANDERS & THOMAS UNIT AHT-64 #143 POSITION 2A OVERALL LEVEL 1.5g FREQUENCY RANGE 2000 HZ

JOB NO. 2041P DATE 3/22/79 ANALYST WK AVERAGE 32 DB -16 INPUT FROM HASH

TEST CONDITION Loaded



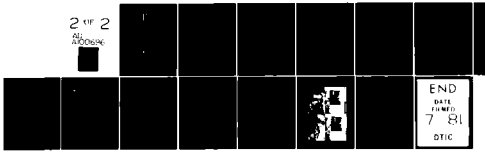
FREQUENCY

VIBRATION SPECIALTY CORPORATION

Figure 29

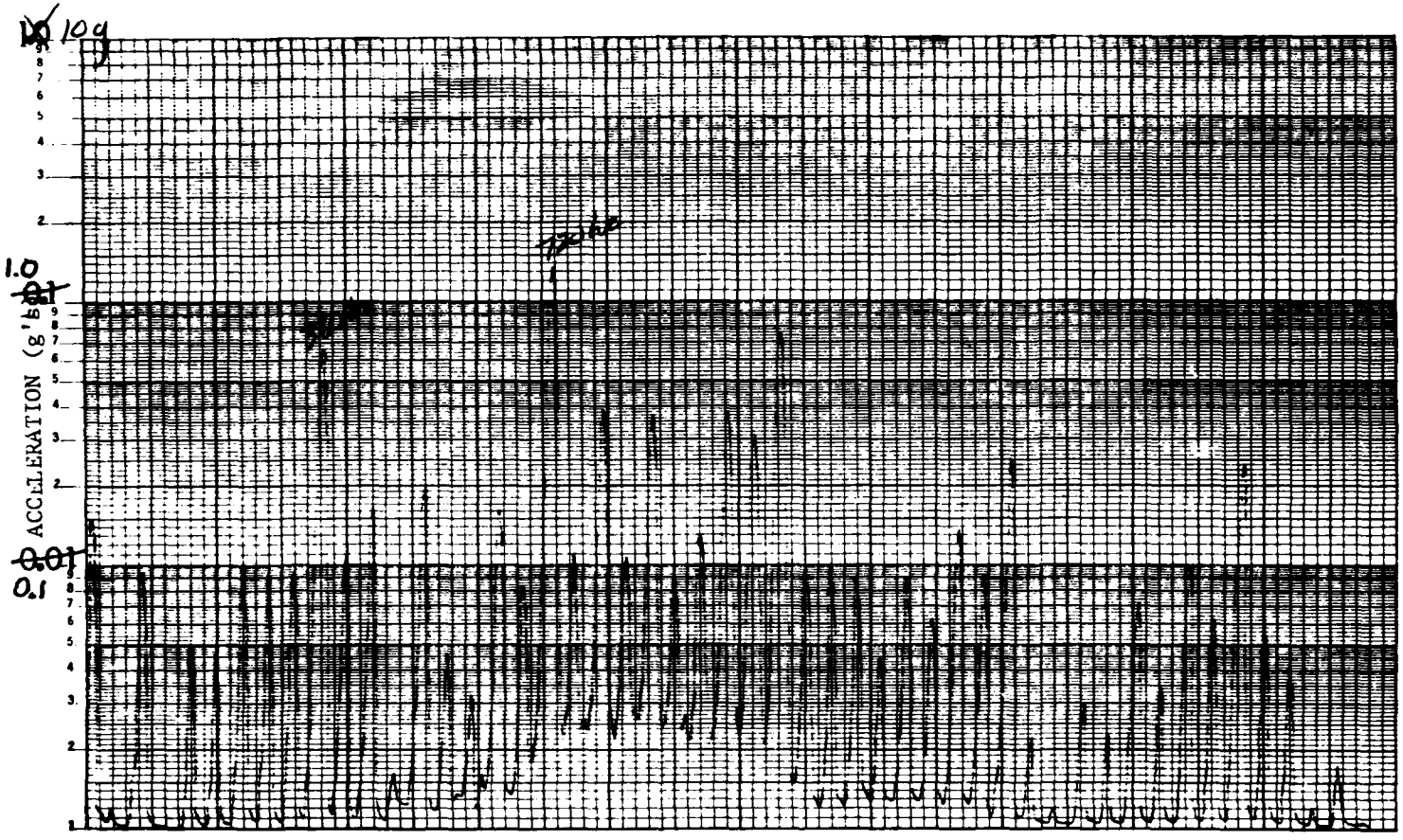
AD-A100 696 SANDERS AND THOMAS INC POTTSTOWN PA F/G 14/2
APPLICATION OF AN IN-LINE CONTAMINATION MONITORING UNIT TO THE --ETC(U)
JUN 81 P M O'DONNELL, E W ROBERTS N00140-80-C-0053
UNCLASSIFIED NAEC-92-146 NL

2 OF 2
AD A100696



END
DATE FILMED
7 81
DTIC

SANDERS & THOMAS EQUIPMENT AHT-64 #143 POSITION 3A OVERALL LEVEL 2g FREQUENCY RANGE 2000 hz
JOB NO. 2041A DATE 3/22/94 ANALYST WK AVERAGE 32 dB -16 INPUT FROM 4A50
TEST CONDITION Loaded



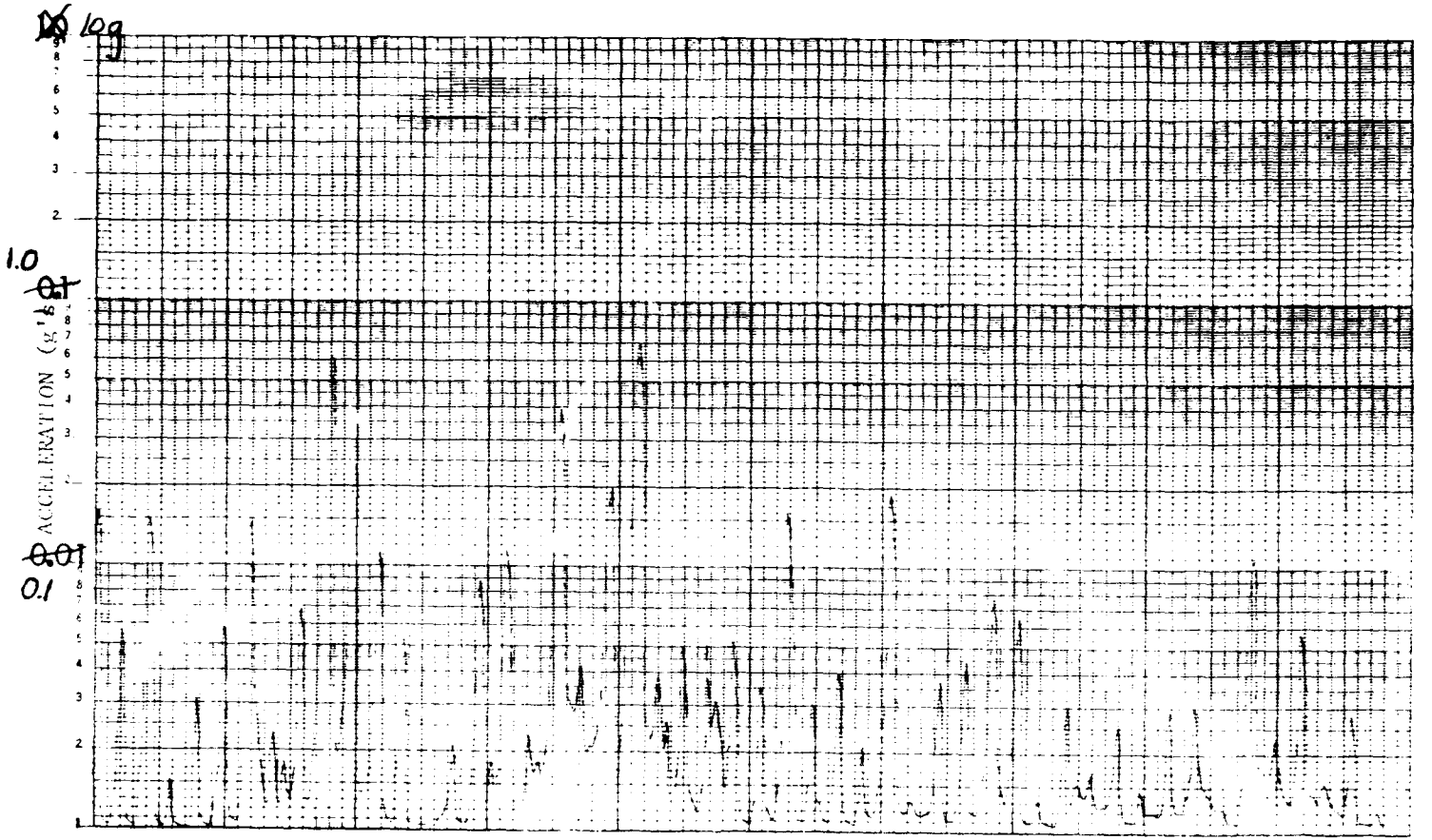
VIBRATION SPECIALTY CORPORATION
100 Geiger Road / Philadelphia Pa 19115 (215) 698 0800

figure 32

SANDERS & THOMAS EQUIPMENT AHT-64 #143 POSITION 4A OVERALL LEVEL 1.4g FREQUENCY RANGE 2000 hz

JOB NO. 20419 DATE 3/22/79 ANALYST WK AVERAGE 32 DB -16 INPUT FROM 4A500

TEST CONDITION Loaded

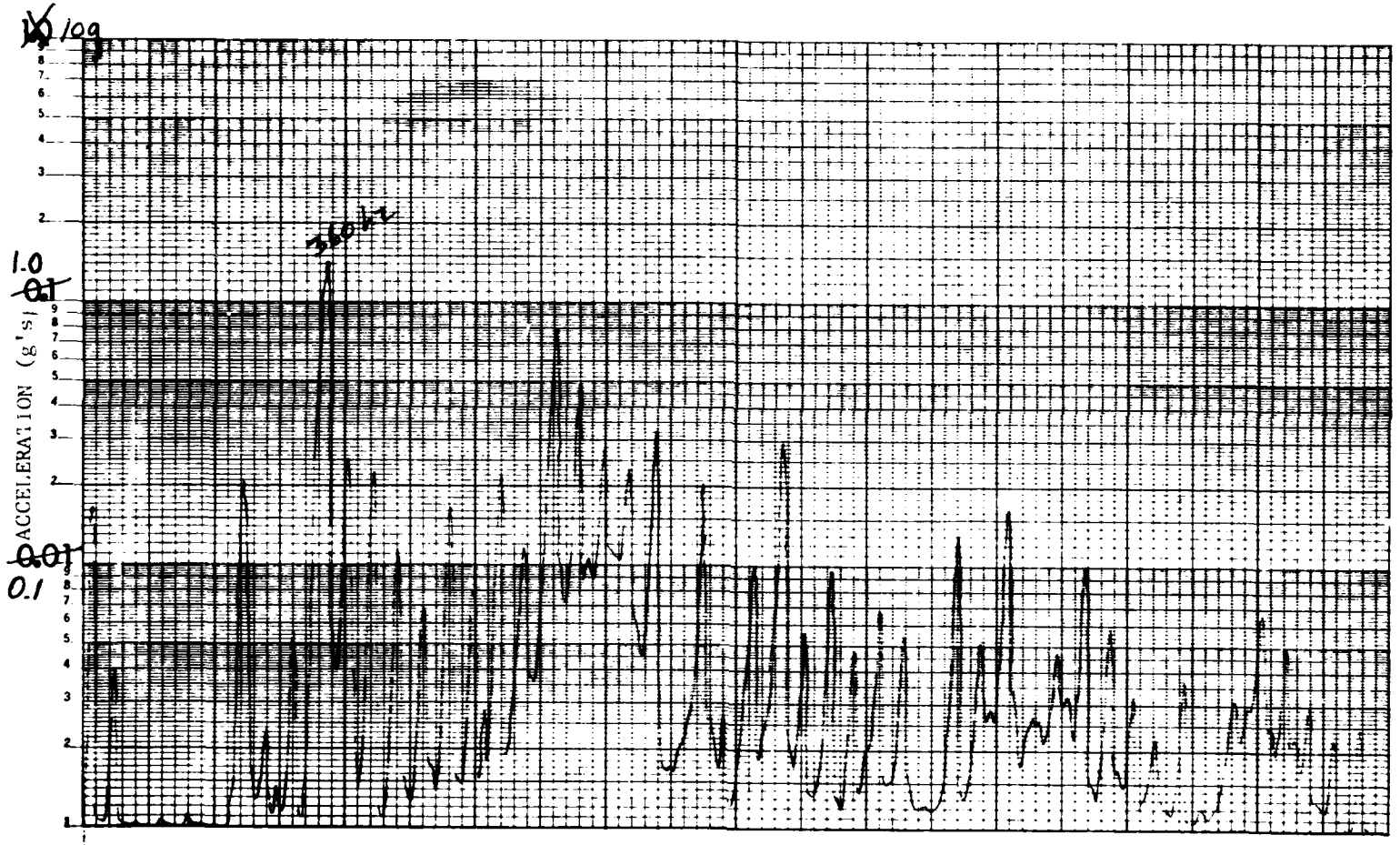


FREQUENCY

VIBRATION SPECIALTY CORPORATION

figure 35

SANDERS & THOMAS AHT-64 #143 5H 2.2g 2000 hz
JOB NO. 20419 DATE 3/22/79 WK AVERAGE 32 -16 UA500
Loaded



VIBRATION SPECIALTY CORPORATION
100 Geiger Road Philadelphia Pa 19115 (215 [illegible])

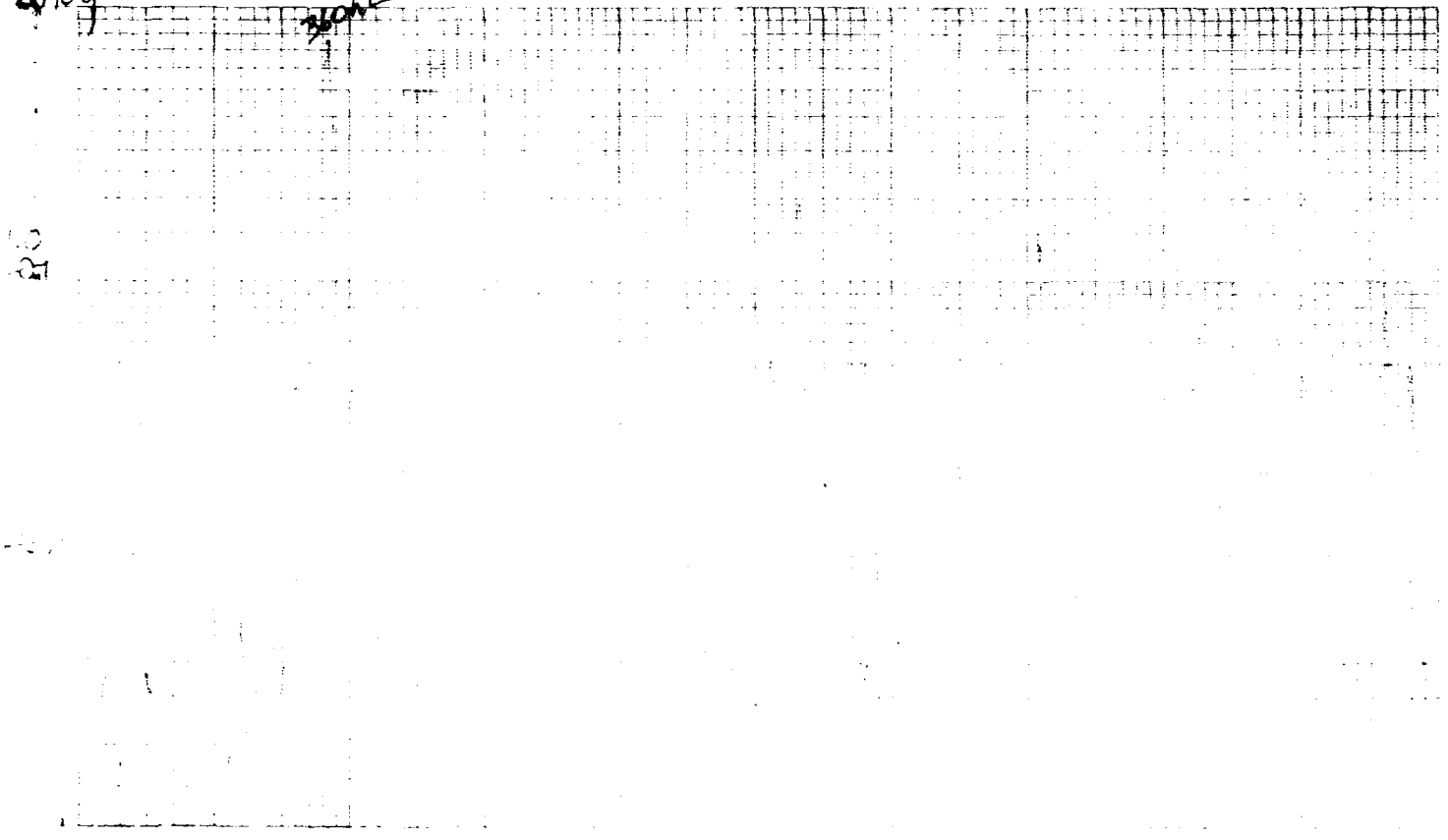
figure 36

SANDERS & THOMAS AHT-64 #143 6A OVERALL LEVEL 13g FREQUENCY RANGE 2000 hz

20419 DATE 3/22/74 ANA WK AVERAGE 32 dB -16 INPUT FROM 4A500

Loaded

10g



FREQUENCY

VIBRATION [illegible] CORPORATION

Figure 4

SANDERS & THOMAS AHT-64 #143 OVERALL LEVEL 7V 11g FREQUENCY RANGE 2000 hz

JOB NO. 20419 DATE 3/22/79 ANALYST WK AVERAGE 32 dB -16 INPUT FROM YA500

Loaded

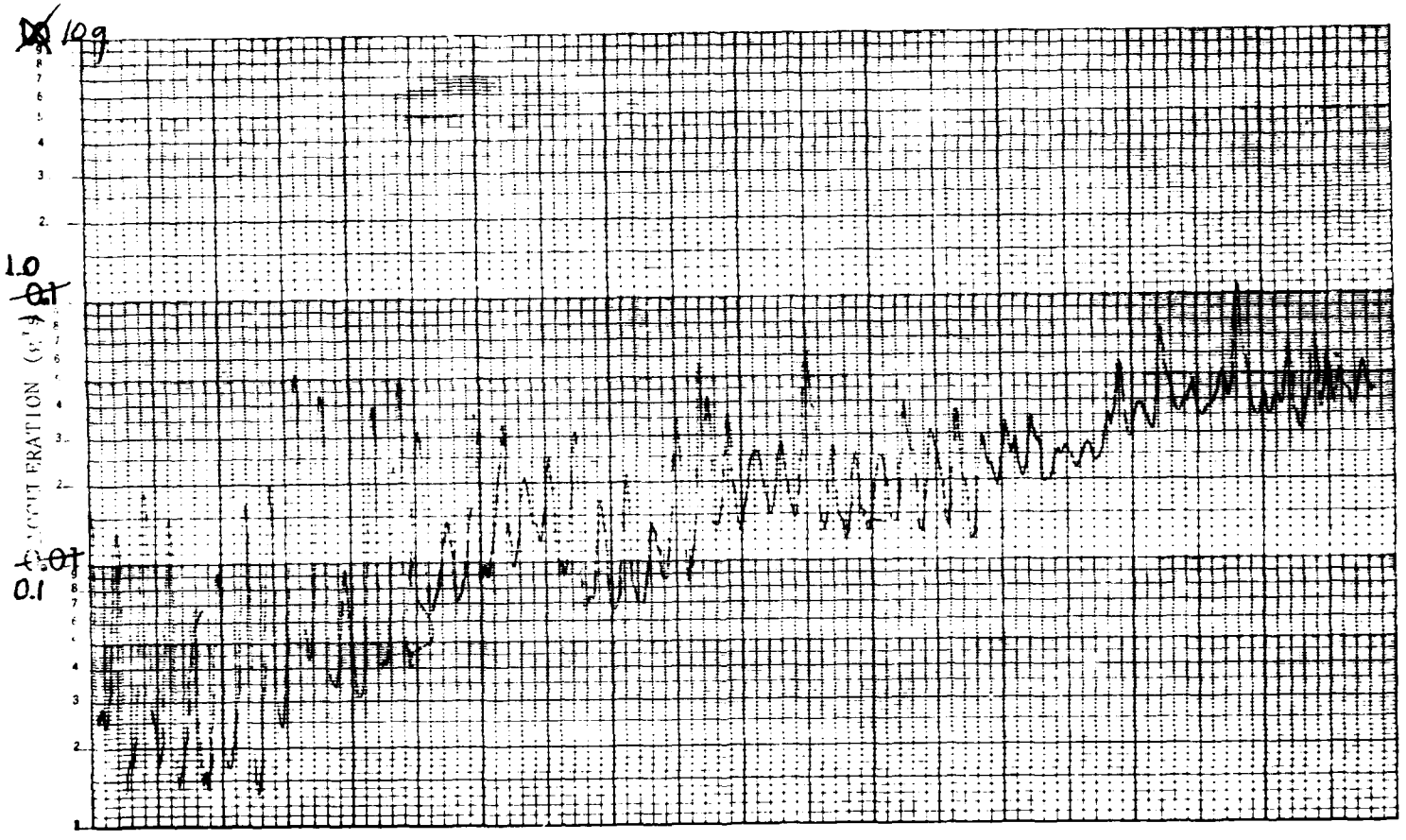


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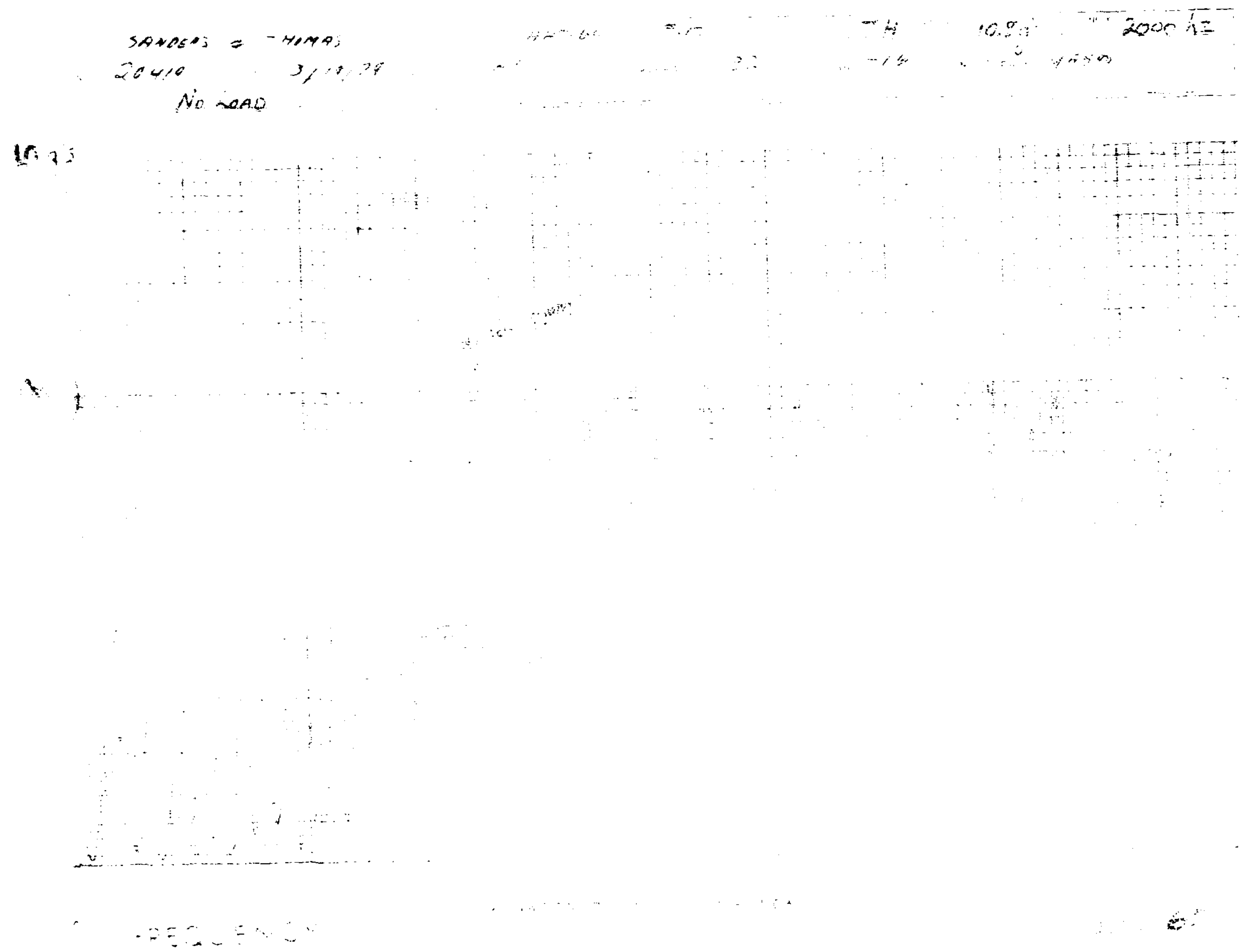
figure 43

(81-8) 36

NAEC-92-146


SANDERS
20410
No LOAD
2000 HZ
FREQUENCY

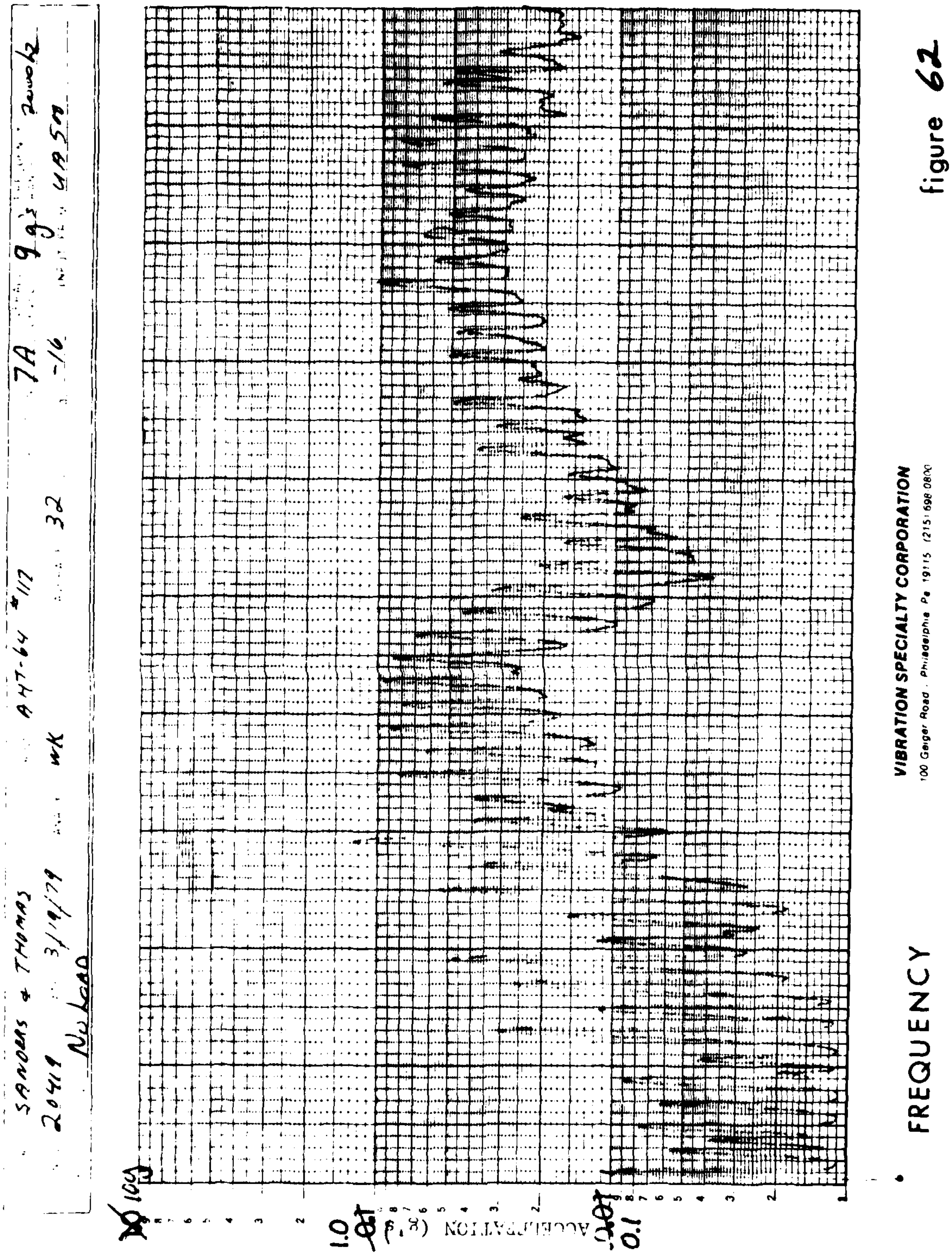
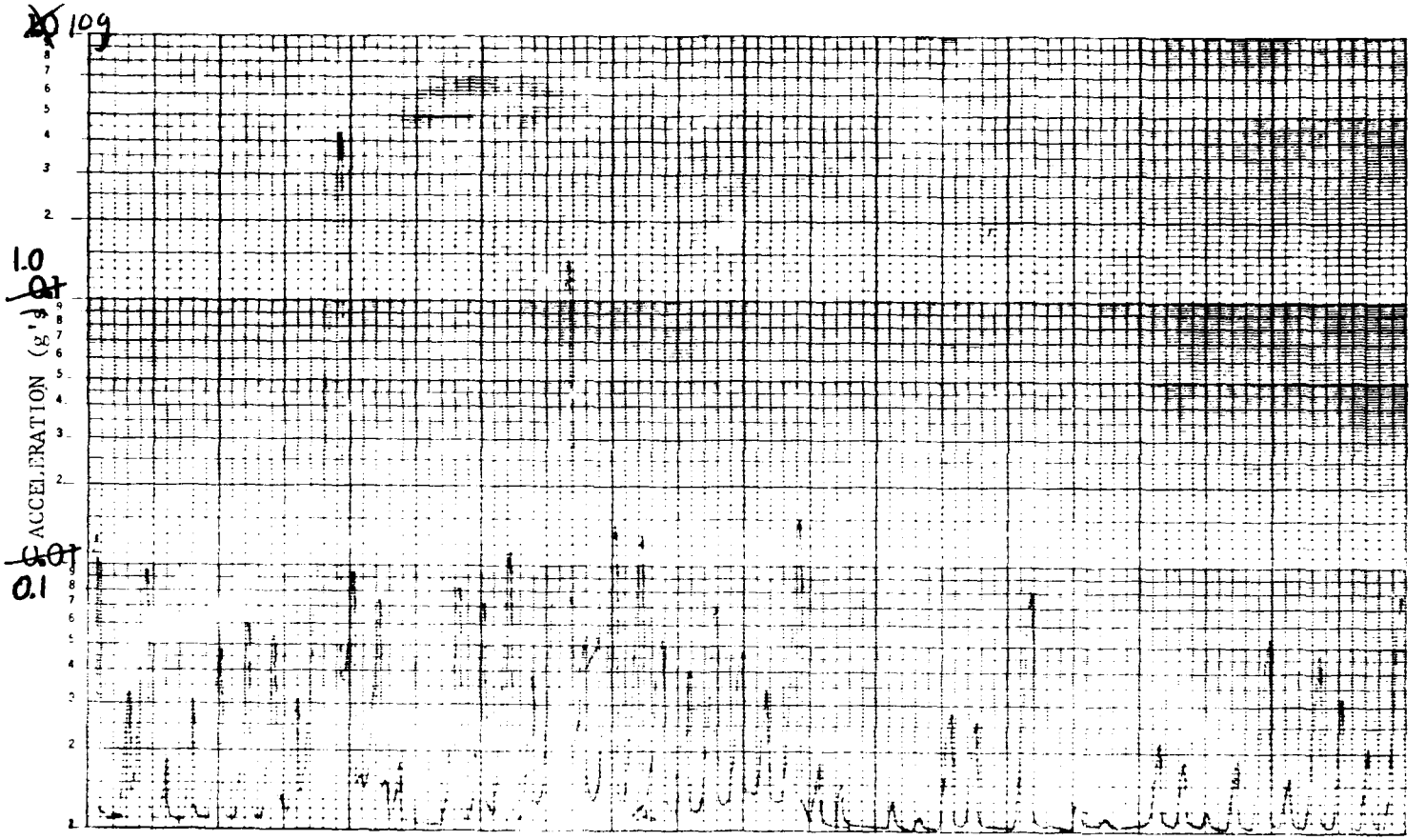

SANDERS & THOMAS
20419
3/19/79
No Load
AH-64 #117
7A
FREQUENCY
ACCELERATION (g's)
VIBRATION SPECIALTY CORPORATION
100 Geiger Road, Philadelphia Pa 19115 (215) 698 0800

figure 62

SANDERS & THOMAS AHT-64 #117 2A 44 g 8000 hz
20419 3/19/79 WK 32 -16 INPUT FROM 4A50
Loaded



VIBRATION SPECIALTY CORPORATION

figure 67

101 (B-21)

SANDERS & THOMAS AHT-64 #117 3H 3.2 20cps
20419 3/19/79 W.K 32 -16 UA500
Loaded

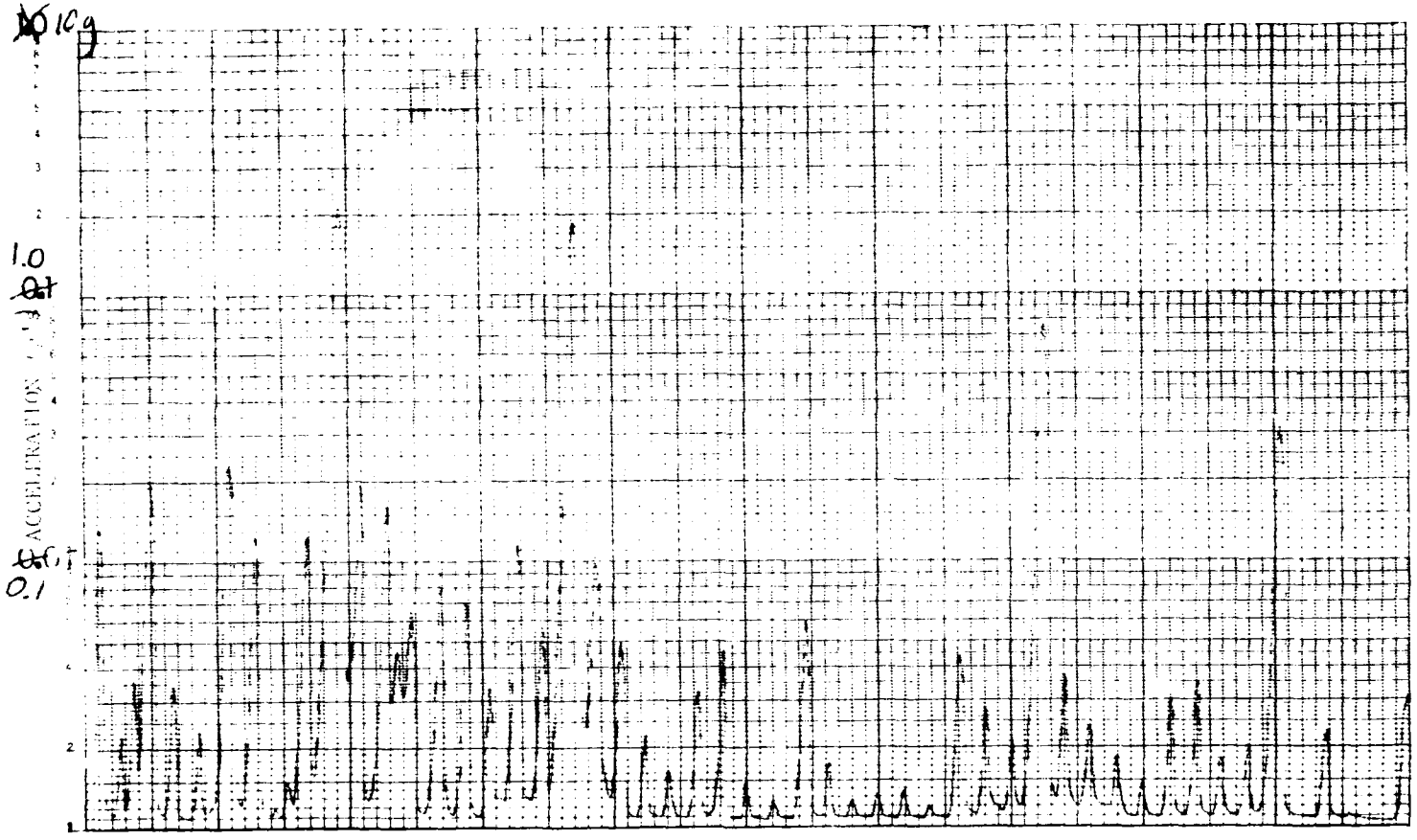


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figure 68

NAEC-92-146

SANDERS & THOMAS AHT-64 #117 4A OVERALL SIZE 7 g's FREQUENCY RANGE 2000 hz

JOB NO. 20419 DATE 3/19/79 ANALYST WK AVERAGE 32 dB -16 INPUT FROM UA500

Loaded

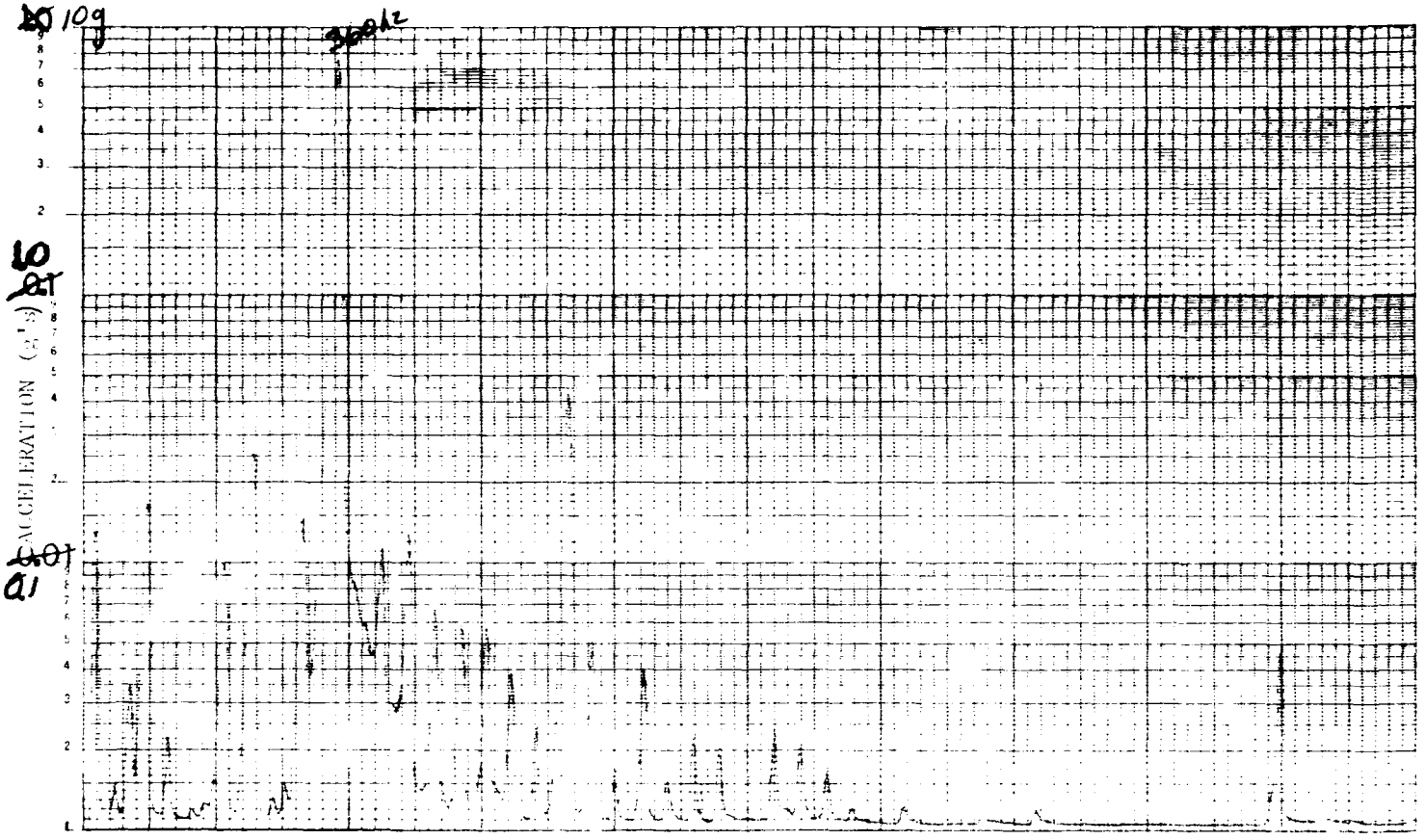

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Figure 73

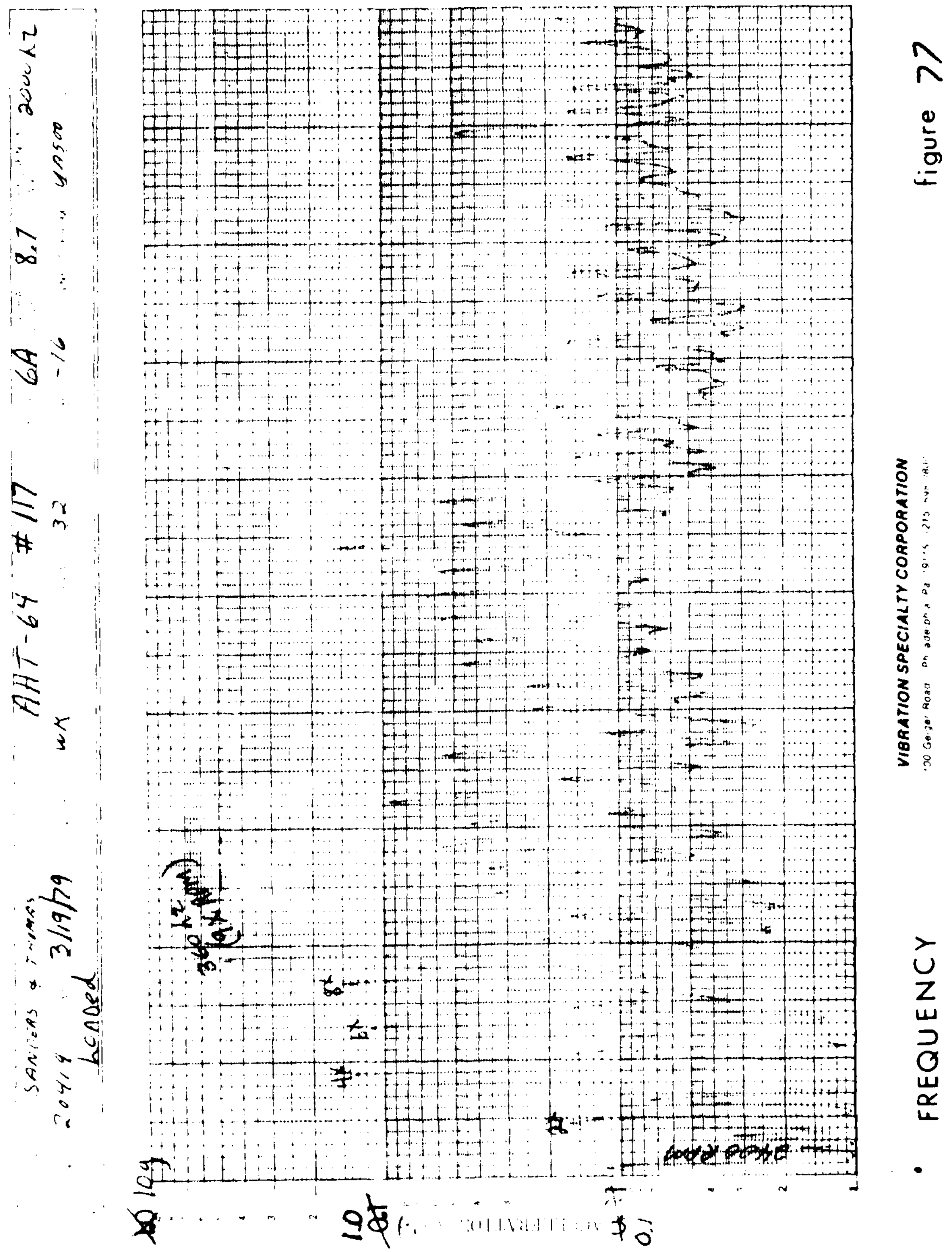
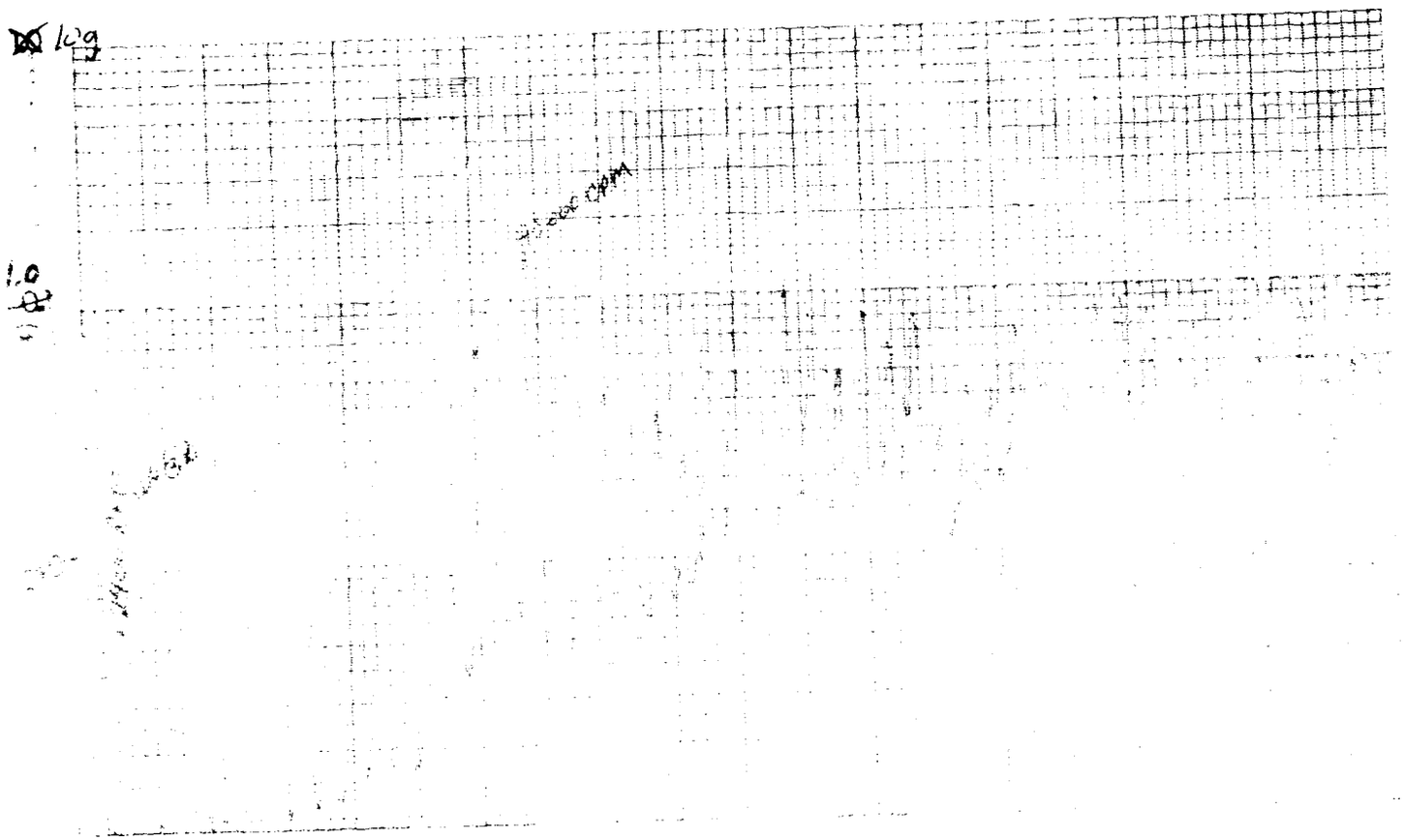

AHT-64 #117
6A
8.7
2000 Hz
3/19/79
loaded
FREQUENCY
ACCELERATION (G)
VIBRATION SPECIALTY CORPORATION

figure 77

SANDERS + THOMAS ANT-64 -117 7H 10 gs 2000 hz

2049 3/19/79 WK 32 -16 VA50

LOADED



APPENDIX C

VIBRATION RESPONSE AND PERFORMANCE OF MONITORS AT VIBRATION SIGNATURE LEVELS OF THE AHT-64 TEST STAND

NAEC-92-145

VIBRATION SPECIALTY CORPORATION
100 GEIGER ROAD PHILADELPHIA PA 19115 · (215) 698-0836, (201) 472-1888

August 27, 1980

Mr. Edwin Roberts
Sanders & Thomas
P.O. Box 50
Lakehurst, New Jersey 08733

Dear Mr. Roberts:

Enclosed is the report of the test conducted on the two oil monitoring systems as furnished by you. We would at any time appreciate the opportunity to serve you again. If you have any questions, please call.

Very truly yours,

Eugene J Schramm

EUGENE J. SCHRAMM
Manager of Engineering
and Technical Services

EJS/mf

Enclosure

The test was conducted in two phases; the first being the Environment One concept and the second being HIAC Pacific Scientific concept.

A. TEST SET UP

The initial test setup is as shown in Picture No. 1 It contained an oil reservoir of approximately three gallons and a motor pump combination capable of delivering up to 10.3 gallons per minute at approximately 20 psi and 3.3 gallons at 100 psi. The piping system was set up with a bypass so that all or any portion of the fluid could be returned directly to the reservoir. Through this method we were able to flow from 1 1/2 gallons per minute up to the maximum of 11 gallons per minute by adjusting the control valve in this line. Two pressure gauges were inserted in the line to monitor the pressure and see if there was a substantial pressure drop through the sensing device. The vibration was imparted to the test article by an electro-magnetic shaker system mounted under a resonant beam that was tuned to 360 HZ. The control accelerometer was used to verify the vibration level and controlled to read 2.2 g's ± 5 percent.

During the initial attempts to calibrate and check out the Environment One concept, problems were encountered with air trapped in the system so that adequate flow and pressure could not be obtained. The reservoir and plumbing were altered slightly by increasing the volume of the reservoir and installing a stand pipe to bleed off any entrapped air. At the same time, the flex hoses were changed from a convoluted type to a smooth interior wall. This enabled us to obtain any flow or pressure combination we desired.

B. TEST PROCEDURE

The following sequence was established for both systems. Due to problems with the HIAC concept, it was necessary to deviate from this procedure. The procedure used on the Environment One unit was as follows:

1) with the unit installed and hooked up for fluid flow,
2) the sensor was positioned on the resonant beam and the controller on the nearby table. Oil was pumped through the system and the meters monitored for response. Approximately 10 minutes were spent at this configuration.
3) Still in the same position, the shaker was activated to impart vibration only to the sensor. The meter was monitored for any changes. Approximately five minutes were spent in this mode.
4) The controller was now positioned on the resonant beam and fastened to the beam.
5) The shaker was again activated and the meter monitored for any change. At all times, the force input was controlled to 2.2 g's. Approximately 10 minutes were spent in this mode.

The procedure for the HIAC was to be the same, but throughout any attempt which included vibrating the sensor, we were unable to obtain any indication that the unit was working. The light on the front of the panel labeled check sensor showed no malfunction as did the alarm. As a last resort, a large quantity of AFD was added to the fluid and pumped through the system for some time. Again, no reading of any kind could be seen. As a precaution, the cable was checked to make sure that it was intact.

C. RESULTS

The results can best be illustrated by Pictures 3 and 4. Throughout any attempt to cause a deviation, the fluid flow test, the vibration test, the loosening and jingling of the sensor, rotating the sensor through 90^{o} and 180^{o}, the readings remained rock steady. The flow meter performed as designed. We reduced the flow to 1.6 gallons and it read 8 percent of full scale. We increased the flow to full flow and it read 52 percent of full scale, or 10.4 gallons. We repeated each condition several times, with it repeating the reading constantly.

Although no attempt was made to rotate the controller, you could pick it up by the handle and move it in any direction; up/down, back forth, with no effect.

The HIAC tests were discontinued at the direction of Mr. Roberts, since no data could be obtained.

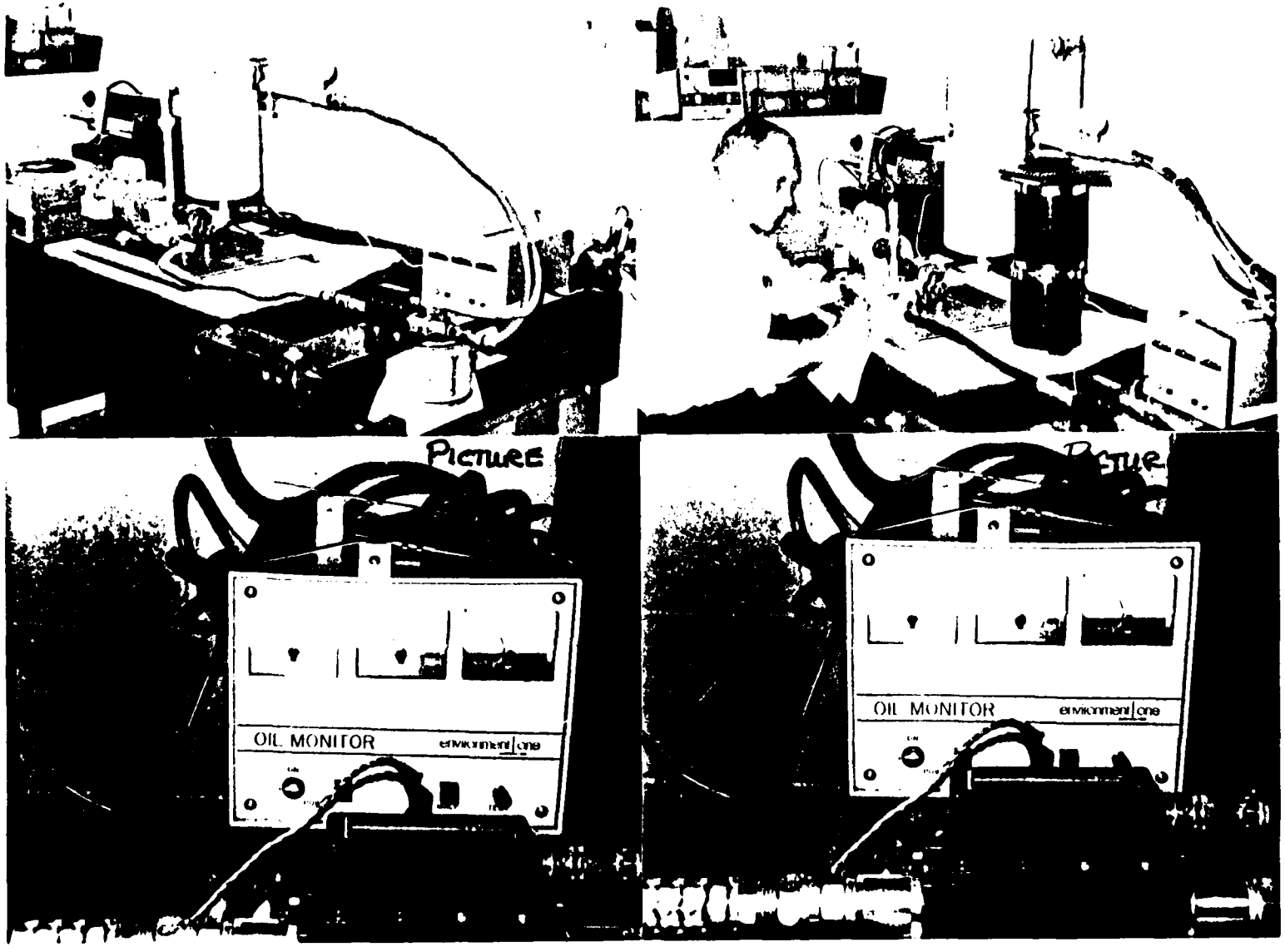
D. CONCLUSIONS

The Environment One unit performed as its specifications delineated and was not effected in any way by the 360 HZ at 2.2g.

The HIAC unit was judged to be unsatisfactory since it would not function at all.

PICTURE 1

PICTURE 2



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